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QUARTERLY

OF THE

National Fire Protection Association

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40 CENTRAL STREET, BOSTON, MASS.

National Fire Protection Association

INTERNATIONAL

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St. Louis Fire Prevention Bureau.
Tennessee Inspection Bureau.
Terminal Elevator Grain Merchants' Association.
Texas Board of Insurance Commissioners.
Texas Inspection Bureau.
The Union.
Underwriters' Association of the District of Columbia.
Underwriters' Association of the Middle Department.
Underwriters' Bureau of Middle and Southern States.
Underwriters' Bureau of New England.
Underwriters' Laboratories.
Underwriters' Service Association.
United States Fireworks Manufacturers' Association.
Washington Surveying and Rating Bureau.
Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association.
Western Insurance Bureau.
Western Sprinkled Risk Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.

Over 4,300 Associate Members

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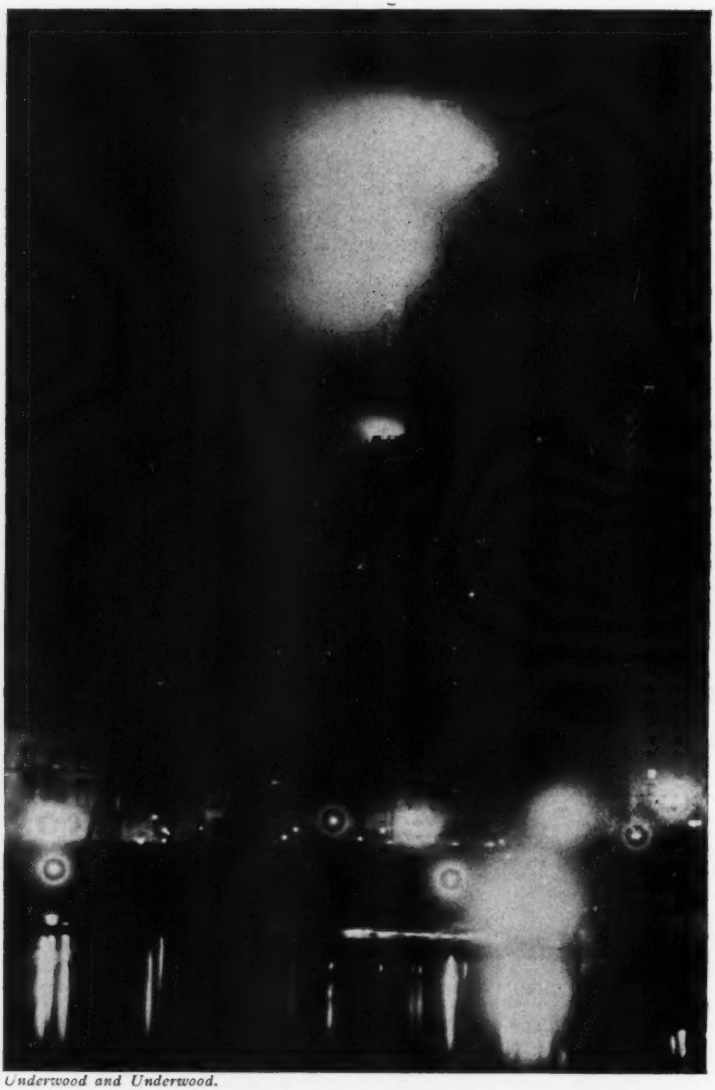
Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.



Underwood and Underwood.

The fire on the tower of the Sherry-Netherlands apartment hotel, New York City, on April 13, showing the burning wood scaffolding and hoists. The fire was inaccessible to the fire department and was an imposing spectacle until it burned itself out after nine hours. (See report on page 93.)

The Quarterly

Vol. 21 July, 1927 No. 1

The Thirty-first Annual Meeting. Once more the attendance at an annual meeting has broken all previous records. The thirty-first annual meeting at Chicago in May exceeded all other conventions in total registration and in continuous attendance at the sessions. The final awakening of industry to the need for checking the fire waste is bringing to our conventions large numbers of interested and influential men whose faces are new to the "old guard" who, persistent and undiscouraged, have so long given their best to the Association's projects. It was natural that the Association's present big enterprise, the extension of our field engineering service, should appear as the high light of the meeting, and the logical and intimate connection of this service with the work of the fire marshals, as well as the safety division managers of the chambers of commerce and the safety council directors tended to emphasize the importance of our field work. Members who read the voluminous *Proceedings,* however, which is now being printed, will be impressed by the fact that all this activity, which may be designated as our civic effort, is most interestingly and competently balanced by our technical and research accomplishments. The committee reports this year were of striking interest and contributed the same fundamental and solid background to the meeting that they always do.

* * * * *

Firecracker Madness. The usual record of fires caused by fireworks used on July 4th—and before and after—is straggling in. The New York Fire Patrol reports 181 fires so caused in New York alone; a child's death from "sparklers" (advertised as harmless), a $50,000 lumber yard fire in Buffalo credited to firecrackers; and so on, *ad nauseum.*

What relation in the modern mind, mature or immature, has this ridiculous playing with fire to the fact of American independence from Great Britain? None. It is simply an orgy; an excuse for the small boy

and girl and the man whose intelligence is still adolescent, to get a thrill out of noise and fire. What more unfortunate direction could any anniversary observance take than the provision of a vehicle of death and destruction for the children and property of a nation? To encourage the observance of fire prevention week in October while refraining from stamping out absolutely the use of fire for private celebration of Independence Day in July convicts us of silliness. So long as undeveloped humanity demands spectacles to gape at, pyrotechnics will be popular. We should, at least, however, have the intelligence to put such displays under competent public direction, and co-operate as parents even if it doesn't appeal to us as citizens, in safeguarding the lives, eyes and fingers of the nation's children, by keeping them out of temptation. Stop selling fireworks to individuals as we've stopped selling revolvers; that is the logical solution.

* * * * *

Why Should They Pay? A recent experience of Philadelphia in attempting to create a fire prevention movement to be financed by insurance companies having their home offices in that city should be an adequate reply to the citizen who assumes that fire prevention is wholly a fire insurance company matter. Following is the story as taken from the *National Underwriter* of June 30th:—

COMPANIES WILL NOT HELP

Effort of Philadelphia Chamber of Commerce to Finance Fire Prevention With Insurance Money Frowned Upon

Insurance company executives have indicated their disapproval of the plan of the Philadelphia Chamber of Commerce to organize a Philadelphia fire prevention association financed by contributions from the fire insurance companies of one-eighth of 1 per cent of their Philadelphia premiums. The presidents of several companies have written to the Chamber of Commerce to the effect that they are contributing through the National Board of Fire Underwriters to educational work on fire prevention, engineering work, detection of arson and the betterment of municipal building codes, and, therefore, are doing their full share in decreasing the nation's fire losses.

The matter of the Philadelphia organization was referred to the National Board, and its executive committee advised the companies in the organization to adhere to the established practice of withholding support from such movements as the Chamber of Commerce plans. The action was not aimed only at the Philadelphia Chamber of Commerce, but also at similar movements started by individuals or business organizations and then turned over to the insurance interests for financing.

Many company executives feel that such movements as the one planned by the Chamber of Commerce should be supported by the municipality, as are the fire departments. If the movements accomplish what their sponsors expect them to accomplish, the benefit will be shared by the citizens, and the fire companies will make their contribution in the form of reduced rates.

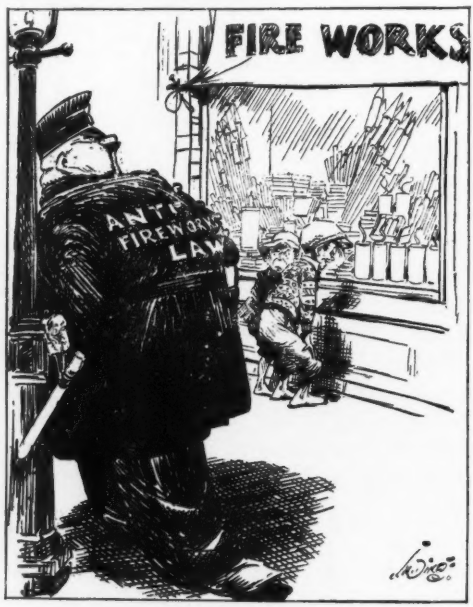
Any thoughtful person must agree that the position taken by the Philadelphia insurance companies is logical. In order to carry on their business successfully and pay fire losses they must collect premiums at rates imposed by the burning records. The premium payers pay for the fire waste, the insurance companies do not. As stated by the General Manager of the National Board of Fire Underwriters in a recent letter to the *New York Times:* "Those who prefer to maintain fire-breeding conditions and 'pay the piper' are privileged to do so." If, as is indicated in the above expressed attitude of the insurance companies, they are willing to make their contribution to fire prevention in the form of reduced rates, is it not clearly up to the municipalities to eliminate their fire-breeding conditions which justify the high insurance rates they so frequently complain of? Also, it should not be forgotten that in the matter of fire insurance no city can be sufficient unto itself. The careful premium payer who doesn't have fires pays for the ones who do; the carefully safeguarded city pays for the slip-shod, fire-breeding one. Fire insurance rates have to be adjusted throughout the country to cover them all, and the conflagration hazards. If this were not so, Baltimore, San Francisco, Salem, Chelsea and a lot of other cities would still be largely in ruins.

* * * * *

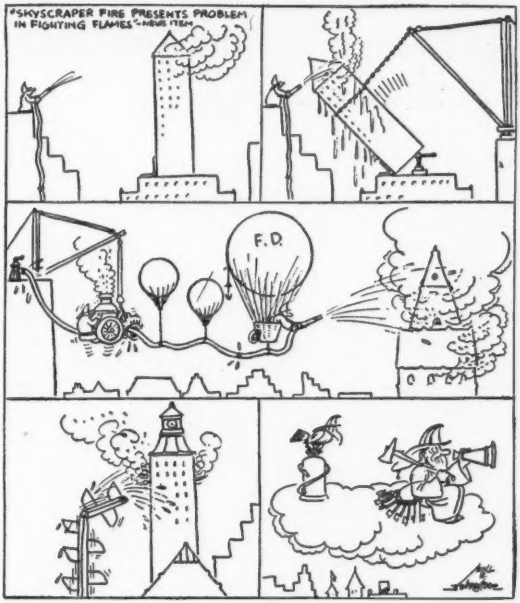
Sprinklers and Life Safety. Those interested in automatic sprinkler protection have for a long time pointed with pride to the fire record of sprinklered buildings, citing statistics to show that practically no lives have been lost by fire in buildings equipped with proper automatic sprinkler protection. The analysis of Loss of Life in Sprinklered Fires, published in the July, 1923, QUARTERLY (Vol. 17, No. 1, p. 58), presented a record of 35,000 fires with 45 in which loss of life had occurred with total casualties of 202. All of these losses of life occurred under conditions where sprinkler control would not be expected, the great majority being explosions or flash fires, with a few instances of water shut off and one building collapse. The Briggs fire, reported in this issue, prevents further conclusive evidence that automatic sprinklers should not be considered a panacea to prevent loss of life by fire under all conditions. They are of the utmost value and importance in safeguarding life as well as property, but it must be recognized that where the hazard is too severe for effective protection of property by a standard sprinkler system, the sprinklers cannot be relied upon always to prevent loss of life by fire.

THE GUMPS—Where There's Smoke There's Fire
I'M SORRY MR GUMP BUT YOU CAN'T SMOKE IN THE HOSPITAL- I DON'T WANT TO DEPRIVE YOU OF ANY PLEASURE BUT YOU'RE ENDANGERING HUNDREDS OF LIVES
TELL ME I CAN'T SMOKE — THIS IS A FREE COUNTRY - AND A BROKEN LEG DON'T PREVENT ME FROM ENJOYING MY RIGHTS AS AN AMERICAN CITIZEN — WHEN THAT NURSE SAID - MY SMOKING WOULD ENDANGER HUNDREDS OF LIVES - SHE MUST HAVE BEEN THINKING OF THE MOSQUITOS-
WHEN EVER I DO ANY SMOKING I'M AS CAREFUL AS THE SUPERINTENDENT OF A POWDER FACTORY- SNIFF! SNIFF?
FIRE!
OH MIN!
SIDNEY SMITH

Sidney Smith in the Chicago *Tribune*



Darling in the New York *Tribune*



Will Johnstone in the New York *World*

AN' GET THOSE OLD BOTTLES AN' THINGS OUT OF THE CELLAR, TOO, WHILE YOU'RE AT IT!!
MISTIS WORKIN' ME EN DE BOSS PLUM TO DEATH CA'SE SHE SKEERED O' FIAR—SHE JES' WELL RESK ONE FIAH EZ TWO FUNEALS!!
FIRE PREVENTION WEEK APRIL 28th

J. P. Alley in the Memphis *Commercial Appeal*

Meetings of Executive Committee.

May 16, 1927.

MEMBERS PRESENT.

Albert T. Bell, Atlantic City, Chairman
Dana Pierce, Chicago, President
Frank C. Jordan, Indianapolis, Vice-President
Allen M. Schoen, Atlanta, Vice-President (by H. N. Pye)
Franklin H. Wentworth, Boston, Secretary-Treasurer.

Eugene Arms, Chicago
William H. Blood, Jr., Boston
George W. Booth, New York
Samuel D. McComb, New York
H. L. Miner, Wilmington, Del.
F. T. Moses, Providence
Hickman Price, New York
Paul W. Terry, St. Louis

Business Transacted.

The report of the Chairman to the Annual Meeting was approved.

The report of the Treasurer was approved.

The Association of Canadian Fire Marshals was elected an organization member.

The following officers of the Fire Marshals Section were appointed:

Stacey W. Wade, North Carolina, Chairman
Hugh H. McLellan, New Brunswick, Vice-Chairman
C. L. Topping, West Virginia, Vice-Chairman
Gabriel Goldwater, Detroit, Vice-Chairman
C. S. Magruder, Ohio, Secretary.

The matter of the fire hazards of construction operations was referred to the Committee on Building Construction for investigation and report with recommendations.

The matter of fire hazards incident to Earthquakes was referred to the Executive Office for consideration and recommendations to the Executive Committee.

June 29, 1927.

MEMBERS PRESENT.

Albert T. Bell, Atlantic City, Chairman
Dana Pierce, Chicago, President
A. M. Schoen, Atlanta, Vice-President
Rudolph P. Miller, New York, Past President
Franklin H. Wentworth, Boston, Secretary-Treasurer.

George W. Booth, New York
George W. Elliott, Philadelphia
C. T. Ingalls, Oklahoma City
S. D. McComb, New York
H. L. Miner, Wilmington, Del.
F. T. Moses, Providence
W. W. Orr, New York
Sumner Rhoades, New York
P. W. Terry, St. Louis
J. S. Trump, Philadelphia

Business Transacted.

The place and dates of the 32nd annual meeting of the Association were set for Atlantic City, May 7, 8, 9, 10, 1928.

A Program Committee was appointed consisting of the President, Secretary and Chairman of Executive Committee.

It was voted to recommend to the next incoming Executive Committee that Memphis be selected as the place of the 33rd annual meeting of the Association.

The Budget for 1927-1928 submitted by the Treasurer was approved.

S. D. McComb and Sumner Rhoades were selected to complete the Nominating Committee 1928.

Chairman S. D. McComb reported progress for the Field Service Fund Campaign Committee.

Proposed regulations governing technical committees were considered, amended and adopted, and recommended for publication in the Year Book.

It was voted to recommend to the Committee on Manufacturing Risks and Special Hazards, which by direction of the Association in annual meeting is preparing a brochure on Spray Finishing Hazards, that the important provisions contained in the present Association pamphlet, Pyroxylin Finishes, be included in such brochure; that such brochure include all spray finishing processes and hazards, with quotation and explanation of existing N.F.P.A. regulations governing the same, including diagrams and other illustrations designed to be helpful to the layman in gaining an adequate idea of the hazards involved in these processes and methods of control of the same. The Secretary was requested to report the preparation of this pamphlet in the *News Letter* with the statement that meanwhile the present pamphlet, Pyroxylin Finishes, and the Regulations on Paint Spraying and Spray Booths, will be found useful to members concerned with spray finishing hazards.

It was voted to adopt the following recommendations of the Committee on Gases affecting the Regulations on Compressed Gas Systems other than Acetylene for Lighting and Heating: viz:

> In Rule 7 (b), Piping, revise the figures 3/16 and 1/32 to read respectively 3/32 and 3/64; the revised rule to read:
>
> (b) In systems of a type in which compressed air in liquid form enters the building only heavy walled seamless brass or copper tubing may be used. Internal diameter of such tubing should not be greater than 3/32 inch and wall thickness not less than 3/64 inch.

The Executive Office was authorized to advance the several regulations under the jurisdiction of the Committee on Dust Explosion Hazards from the A.E.S.C. status of, "Tentative American Standard" to the status "American Standard" this change to be made in the several standards as they are revised and reprinted.

It was voted to instruct the Chairman of the Committee on Hazardous Chemicals and Explosives to proceed with the development of the proposed table of hazardous chemicals and explosives along the lines already projected.

It was voted to change the name of the Committee on Fire Prevention Week to "Fire Prevention and Clean-up Campaign Committee."

The Executive Office was authorized to make changes in the Safety Code for Protection Against Lightning to be submitted by A. M. Schoen, Chairman of the Committee on Lightning Protection.

The matter of co-operation in the production of a fire prevention educational film by the Eastman Kodak Company was referred to the Executive Office for favorable consideration.

The Executive Office was authorized to create a Chamber of Commerce and Safety Council Section of the Association with the first officers as follows:

Chairman: Clifford Penland, Memphis Chamber of Commerce.
Secretary: Harry L. Shearer, Detroit Board of Commerce.

The Executive Office was authorized to create and complete the roster of the following new committees:

(a) Visual Education: Richard E. Vernor, Chairman
(b) Earthquake Fire Hazards
(c) Construction Operation Fire Hazards.

Existing committees were reviewed in the light of the recommendations of their chairmen, and changes in the personnel of the same will appear in the forthcoming Year Book.

The Fourth of July.

Has your city a fireworks ordinance under which patriotism can be sane?

THE OLD WAY

An annual orgy of noise and fire and death.

Morris in *The American City*

THE NEW WAY

Public celebrations in open spaces under municipal supervision.

The 1926 Fire Loss.

The total U. S. fire loss for 1926 was $560,548,642 according to the estimates of the Actuarial Bureau of the National Board of Fire Underwriters (Member N.F.P.A.) as presented in the current report of their Committee on Statistics and Origin of Fires. The per capita loss of the country as a whole is set at $4.79, the lowest since 1923. For 377 cities over 20,000 population the average loss per capita is given as $3.35.

The per capita fire losses of the cities of over 100,000 population over a five-year period as given in the reports of the above committee follow. The figures given are for the most part fire department estimates and as such may be somewhat lower than the losses reported by the insurance companies. For example, the fire department in New York City estimated its loss as approximately $21,700,000 for 1926. This figure was used in working out the 1926 figure for New York in the following table. However, the losses returned by the insurance companies in New York in 1926 are reported as about $29,700,000, or some 37% more than the fire department estimate. In some cities where accurate figures are compiled by the salvage corps, the fire department uses these figures in reporting. Of the largest cities, Philadelphia, Chicago and Boston, for example, report the salvage corps figures; the losses in Buffalo, Pittsburgh, Cleveland, Los Angeles, Detroit and others are apparently fire department estimates.

Per capita fire loss statistics, while not conclusive if taken for a single city for a single year are, however, valuable for comparison if taken over several years. A bad per capita record for a single year, especially in the smaller cities, may be the result of a single large fire. A continued high burning record for a city over several years is, however, an almost certain indication of the true conditions.

In the following tables, the cities are arranged in population groups, and in each group in the order of their per capita loss in 1926.

PER CAPITA FIRE LOSSES.

	1922	1923	1924	1925	1926
Entire U. S.[1]	$4.63	$4.84	$4.90	$4.85	$4.79
Average for cities[2]	$3.57	$3.42	$3.37	$3.53	$3.35
(No. cities averaged)	366	372	366	377	377

[1]Estimated from records of Actuarial Bureau of National Board of Fire Underwriters.

[2]Losses reported by fire departments.

Cities over 500,000 Population.

	1922	1923	1924	1925	1926
Boston, Mass.	$4.34	$8.18	$6.19	$6.97	$6.59
Chicago, Ill.	2.66	1.97	2.23	3.75	4.86
Buffalo, N. Y.	4.61	5.24	5.01	5.79	3.84
New York, N. Y.	3.88	3.31	3.16	3.21	3.66
Pittsburgh, Pa.	3.29	2.23	3.58	3.43	3.37
St. Louis, Mo.	4.42	3.45	4.15	3.95	3.09
Baltimore, Md.	5.52	2.18	2.45	2.66	3.07
Philadelphia, Pa.	2.69	4.11	2.38	3.23	2.93
Milwaukee, Wis.	3.17	3.91	2.94	2.84	2.64
Cleveland, Ohio	2.70	2.18	2.41	2.97	2.46
Detroit, Mich.	2.21	3.99	3.17	3.16	2.73
Los Angeles, Calif.	1.54	1.67	1.61	1.47	1.77
San Francisco, Calif.[1]					

Cities from 400,000 to 500,000 Population.

Newark, N. J.	$3.60	$4.14		$7.42	$5.67
Kansas City, Mo.	9.17	7.18	$6.95	8.95	4.13
Cincinnati, Ohio	3.91	3.24	2.71	2.65	3.16
Washington, D. C.	2.43	4.92	1.78	1.74	3.11
Minneapolis, Minn.	3.75	3.82	4.23	3.64	3.10
New Orleans, La.	13.03	1.81	2.12	7.59	1.42
Seattle, Wash.	1.62	1.51	1.66	3.66	1.40

Cities from 300,000 to 400,000 Population.

Louisville, Ky.	$3.68	$6.69	$3.51	$4.46	$4.30
Columbus, Ohio	2.62	3.94	1.91	1.89	3.12
St. Paul, Minn.	4.87	5.13	4.99	4.16	3.10
Portland, Ore.	5.31	4.51	3.48	3.69	3.01
Oakland, Calif.	1.55	2.59	4.66	1.38	1.87
Indianapolis, Ind.	2.52	4.23	3.47	3.38	1.82
Rochester, N. Y.	1.88	1.86	3.06	1.71	1.51
Denver, Colo.	2.61	2.12	3.02	1.96	1.42
Jersey City, N. J.	1.14	.97	5.15	1.84	.76

Cities from 200,000 to 300,000 Population.

Dallas, Texas	$10.65	$10.06	$7.88	$9.27	$7.60
Worcester, Mass.	1 98	3.52	3.61	3.03	4.97
Houston, Texas	4.28			3.89	4.16
Atlanta, Ga.	5.27	2.80	4.60	4.64	3.80
Providence, R. I.	2 21	7.21	4.29	2.28	3.78
Toledo, Ohio	4.59	4.52	2.31	4.30	3.57
Memphis, Tenn.	11.97	6.04	4.13	5.44	3.36
Omaha, Nebr.	4.46	11.43	4.28	2.43	3.08
Richmond, Va.	4.15	2.05	2.53	2.74	2.75
San Antonio, Texas	1.26	1.27	1.57	2.28	.99
Akron, Ohio	1.61	2.46	1.02	1.99	.91
Camden, N. J.	1.31	1.07	3.85	.34	.28

[1]Does not report its losses.

Cities from 150,000 to 200,000 Population.

	1922	1923	1924	1925	1926
Paterson, N. J.	$6.17	$2.78	$3.47	$2.91	$7.45
Dayton, Ohio	1.06	1.58	.91	1.27	6.29
Scranton, Pa.	2.68	3.91	4.24	5.36	4.47
New Haven, Conn.	3.53	2.90	5.43	3.83	4.18
Syracuse, N. Y.	2.11	4.81	2.66	1.60	3.90
Ft. Worth, Texas	6.28	4.72	9.54	8.65	3.44
Flint, Mich.	1.41	2.99	2.05	3.19	3.23
Springfield, Mass.	4.02	6.14	2.82	2.76	3.10
Birmingham, Ala.	4.24	4.56	4.83	4.45	3.07
Hartford, Conn.	1.67	1.45	3.43	1.86	3.00
Jacksonville, Fla.	2.78	2.35	3.67	3.23	2.94
Youngstown, Ohio		3.94	3.69	3.12	2.63
Des Moines, Iowa	4.68	2.36	5.50	4.51	2.59
Grand Rapids, Mich.	4.71	8.03	6.90	4.98	1.90
Norfolk, Va.	11.47	4.91	3.04	2.52	1.79

Cities from 125,000 to 150,000 Population.

Nashville, Tenn.	$9.88	$6.55	$4.52	$6.41	$6.83
Miami, Fla.					4.91
Tampa, Fla.	5.85	2.16	2.38	5.93	4.89
Fall River, Mass.	1.62	1.57	3.37	2.11	4.71
Spokane, Wash.	4.13	4.64	5.26	2.69	4.41
Oklahoma City, Okla.	2.00	4.79	1.78	1.80	3.52
Salt Lake City, Utah	2.42	2.14	3.17	2.24	2.98
Chattanooga, Tenn.	4.92	2.10	3.64		2.65
Bridgeport, Conn.	1.02	.55	1.44	1.25	1.90
Tacoma, Wash.	4.43	2.15	4.22	2.34	1.83
Kansas City, Kansas	1.39	1.13	2.77	1.50	1.76
Trenton, N. J.	1.87	2.04	1.85	3.37	1.42
Long Beach, Calif.	.65	.44	1.67	1.03	1.08
Erie, Pa.	4.09	2.61	1.63	2.36	1.04
Tulsa, Okla.	1.82	1.72	1.71	1.64	.99

Cities from 100,000 to 125,000 Population.

Lowell, Mass.	$4.10	$5.44	$8.66	$3.13	$14.43
So. Bend, Ind.	6.22	4.05	2.63	5.58	7.59
Reading, Pa.	1.46	4.47	1.74	2.86	6.26
Duluth, Minn.	2.97	6.52	3.73	5.71	5.41
Cambridge, Mass.	5.74	3.85	7.15	3.07	5.38
Lynn, Mass.	3.59	4.13	11.71	4.40	4.78
Waterbury, Conn.	1.55	1.85	1.29	3.76	3.92
Gary, Ind.	2.65	.80	1.41	5.96	3.39
El Paso, Texas	1.23	1.51	2.68	2.21	3.27
Elizabeth, N. J.	2.23	2.96	1.58	3.48	3.22
New Bedford, Mass.	2.52	2.21	9.72	2.64	2.99
Somerville, Mass.	4.71	2.33	2.22	4.13	2.57
Ft. Wayne, Ind.	1.21	1.90	7.58	3.59	2.10
Utica, N. Y.	2.81	5.01	3.00	3.01	1.94

Cities from 100,000 to 125,000 Population, Continued.

	1922	1923	1924	1925	1926
Yonkers, N. Y.	$2.02	$1.51	$1.56	$1.42	$1.89
Sacramento, Calif.	2.22	4.35	6.10	1.84	1.65
Savannah, Ga.	4.66	6.52	1.38	2.60	1.09
Wilmington, Del.	4.25	1.28	1.95	1.43	.65
Canton, Ohio	.49	3.61	1.84	.93	.62

Smaller Cities with High Per Capita Fire Records.

Cities from 50,000 to 100,000 Population.

(The 12 cities of the 94 in this group having the worst records)

Mobile, Ala.	$1.46	$4.01	$4.19	$5.22	$20.39
Haverhill, Mass.	6.46	8.56	5.03	6.22	11.85
Davenport, Iowa	6.22	2.47	4.83	2.86	8.14
Lancaster, Pa.	2.08	8.94	2.60	17.51	7.73
Springfield, Ill.	4.02	6.21	10.78	6.11	7.50
Charlotte, N. C.	13.65	14.81	6.44	5.51	7.39
East St. Louis, Ill.	2.19	3.16		6.55	7.26
Macon, Ga.	3.43	1.85	6.54		6.67
Shreveport, La.	5.81	6.08	7.44	15.77	5.15
Little Rock, Ark.	2.29	3.36	10.24	5.48	4.89
Springfield, Mo.	1.69	9.85	9.02	4.99	3.31
Peoria, Ill.	24.84	4.59	8.43	10.82	2.32

Cities from 35,000 to 50,000 Population.

(The 8 cities of the 85 in this group having the worst records)

Council Bluffs, Iowa	$11.07	$2.82	$4.15	$29.67	$27.77
Raleigh, N. C.	7.61	1.06	2.17	10.74	10.98
Chelsea, Mass.	5.20	10.61	6.24	4.45	7.89
Revere, Mass.	2.62	5.67	4.74	4.27	6.26
Montgomery, Ala.	2.79	15.03	4.92	3.47	5.73
Everett, Mass.	1.95	7.14	2.88	8.01	5.57
Danville, Ill.	2.67	5.92	3.13	5.35	5.37
Wilmington, N. C.	6.06	5.40	10.74	7.84	4.50

Cities from 20,000 to 30,000 Population.

(The 13 cities of the 92 in this group having the worst records)

Gloucester, Mass.	$3.01	$2.51	$5.07	$7.30	$11.28
Kokomo, Ind.	1.11	5.34	11.20	1.19	10.86
E. Liverpool, Ohio	1.27	.98	1.36	22.31	9.64
Peabody, Mass.	14.25	1.57	8.56	13.19	9.11
New London, Conn.	1.40	5.60	3.51	7.85	6.63
Marion Ind.	1.69	13.00	15.21	3.64	6.34
Meridian, Miss.	5.18	3.84	10.03	4.12	6.29
Bellingham, Wash.	3.19	4.34	20.88	18.54	5.99
Alton, Ill.	7.52	7.18	5.47	7.38	5.63
Leominster, Mass.	3.50	9.45	3.49	14.09	5.23
Concord, N. H.	13.37	11.14	4.91	4.90	4.17
Oswego, N. Y.	4.95	5.37	4.93	12.02	4.16
Vicksburg, Miss.	2.50	6.46	10.85	10.90	3.19

Losses Lower for First Half of 1927.

The fire losses in the United States and Canada for the first six months of 1927 were $176,919,000, which is $52,000,000 less than for the same period of last year, according to the estimate compiled by the New York *Journal of Commerce*. These figures are based on estimates of fires with losses of $10,000 or over, with a percentage added to cover small and unreported losses. The figures are not so accurate as, and are usually about a third smaller than, the statistics compiled by the Actuarial Bureau of the National Board of Fire Underwriters, but are immediately available and valuable for purposes of comparison. The 1927 losses, with similar figures for preceding years, are reported by the *Journal of Commerce* as follows:

	1923	1924	1925	1926	1927
January	$36,614,850	$41,243,600	$41,210,400	$41,118,750	$37,910,000
February	42,774,800	31,447,900	32,472,000	30,963,750	26,285,000
March	41,159,650	28,406,150	33,346,500	42,854,600	26,807,000
April	32,638,150	31,815,900	37,696,800	52,408,400	39,723,000
May	34,015,850	27,832,300	29,170,800	32,764,200	20,713,000
June	34,851,900	20,350,400	23,650,800	28,676,000	25,481,000
Total six months	$221,055,200	$181,096,250	$197,547,300	$228,785,700	$176,919,000
Total for year..	$389,192,200	$377,529,250	$373,500,550	$393,020,500	

Annual Fire Losses in the United States for Fifty Years.

Year	Property Loss	Year	Property Loss	Year	Property Loss
1877	$68,265,800	1894	$140,006,484	1911	$217,004,575
1878	64,315,900	1895	142,110,233	1912	206,438,900
1879	77,703,700	1896	118,737,420	1913	203,763,550
1880	74,643,400	1897	116,354,575	1914	221,439,350
1881	81,280,900	1898	130,593,905	1915	172,033,200
1882	84,505,024	1899	153,597,830	1916	258,377,952
1883	100,149,228	1900	160,929,805	1917	289,535,050
1884	110,008,611	1901	165,817,810	1918	353,878,876
1885	102,818,796	1902	161,078,040	1919	320,540,399
1886	104,924,750	1903	145,302,155	1920	447,886,677
1887	120,283,055	1904	229,198,050	1921	495,406,012
1888	110,885,665	1905	165,221,650	1922	506,541,001
1889	123,046,833	1906	518,611,800	1923	535,372,782
1890	108,993,792	1907	215,084,709	1924	549,062,124
1891	143,764,967	1908	217,885,850	1925	559,418,184
1892	151,516,098	1909	188,705,150	1926	560,548,624
1893	167,544,370	1910	214,003,300		

NOTE:—Previous to 1916 figures obtained from the Records of the New York *Journal of Commerce*, deducting the Canadian losses. Subsequent years based on returns to the Actuarial Bureau of the National Board of Fire Underwriters, adding 25% for unreported and uninsured losses.

Canadian Fire Losses, 1926.

Fire losses in Canada during the year 1926 were lower than those of the preceding year, the total losses showing a progressive decrease since 1922, according to statistics compiled by the Dominion Fire Prevention Association and given in the tables printed below. The 1926 losses are nearly 30 per cent below the high point of 1922, despite the increase in the number of buildings and the amount of property subject to destruction by fire. The first table is of particular interest in that it shows the total cost of fire increased about 2½%, despite the 30% decrease in the actual fire losses. While the fire losses have been decreasing, the savings on this account have been balanced by the progressive increase in insurance premiums in excess of losses paid, and by somewhat increased expenditures for public and private fire protection.

What Fire Cost Canada in the Past Five Years.

	1922	1923	1924	1925	1926
Value of Property Destroyed	$54,390,688	$48,282,354	$45,906,531	$40,729,724	$38,395,096
Insurance Premiums in excess of Losses Paid	16,529,907	20,472,375	21,590,380	27,246,031	30,884,862
Maintenance Cost of Municipal Fire Protection	23,247,950	24,170,420	24,659,204	25,103,246	25,970,803
Installation and Maintenance Cost of Private Fire Protection	8,431,050	8,873,200	8,994,500	9,374,815	9,846,725
Total	$102,599,595	$101,798,349	$101,150,615	$102,453,816	$105,097,486

A Decade of Fire Losses in Canada.

Year	Property Loss	Per Capita	Year	Property Loss	Per Capita
1917	$26,298,400	$3.32	1923	$48,282,000	$5.36
1918	33,870,000	4.12	1924	45,906,500	4.99
1919	25,216,300	3.00	1925	40,729,724	4.35
1920	28,081,200	3.27	1926	38,395,096	4.15
1921	45,015,900	5.22			
1922	54,390,000	6.11	Total	$386,185,420	$43.89

Municipal Group Classification, 1926.

	Total Loss	Per Capita
Cities over 10,000 population	$13,524,947	$3.84
Towns 5,000 to 10,000 population	2,687,591	5.32
Towns 1,000 to 5,000 population	2,946,883	4.77
Villages under 1,000	5,192,436	4.58
Rural districts	14,046,953	3.11

Occupancy Group Classification, 1926.

Group	No. of Fires	Property Loss
Manufacturing risks	1,062	$9,116,972
Mercantile stores	3,738	8,306,434
Residential properties	18,581	8,321,006
Farm property (other than dwellings)	3,563	5,417,841
Institutional buildings	397	1,076,090
Miscellaneous property	3,126	6,156,753

Origin of Fires in Canada, 1926.

	Causes Reported	No. of Fires
1.	Overheated stoves, furnaces and pipes	3,273
2.	Sparks on roofs	2,516
3.	Smoking	2,162
4.	Electrical defects	2,028
5.	Lightning	1,627
6.	Defective chimneys and flues	1,573
7.	Carelessness with matches	1,449
8.	Coal-oil and gasoline	986
9.	Hot ashes and coals	554
10.	Portable lamps and lanterns	498
11.	Open grate fires	372
12.	Spontaneous combustion	339
13.	Incendiarism	246
14.	Miscellaneous known causes	5,916
15.	Unknown causes	6,928
	Total	30,467

American and French Fire Protection.

By Paul Vanginot.

Chief of the Fire Brigade (Retired), Paris, France.

The principal differences between fire protection methods in Europe and in America are explained very largely by the social and historical background of these two parts of the world. In Europe growth of cities and nations was relatively slow and the present development is that of ten or fifteen centuries of feeling the way. While there was no conscious establishment of any great number of building rules, the increasing scarcity of wood for construction automatically eliminated a fire hazard of the first order. In America on the other hand, the entire country was built up in an amazingly short time as compared with the development of Europe. Buildings were constructed rapidly and carelessly with a large proportion of wood and without fire stops of any kind so that fires which have broken out have attained proportions nearly unknown in Europe.

A generally milder climate for the same latitudes in Europe by lessening the need for heating equipment tends to remove a large number of fire causes. Then there is the difference in the character of the people. The average Frenchman is still economic and prudent. He does not like to waste his money or his goods, and other Europeans are quite similar. In contrast to this is the average American who is commonly wasteful and of a hardy character and indifferent to dangers. He ignores the fire hazard along with many other dangers. Also he does not look upon fire as the crime against the community that is considered in Europe, where neighbors watch one another more than in America. This fact, together with the fact that merchandise is scarcer, prices higher, and insurance companies more particular as to the risks they accept and the losses they pay, may explain why the writer is advised by the chiefs of American fire departments whom he has met and from what he reads in professional publications that the crime of arson is much more common in America than Europe.

Somewhat offsetting the better attitude of European people toward fire is the serious lag in the provision of proper regulations and protection

This is the translation of an article written for the QUARTERLY by Mr. Vanginot whose full title prior to his retirement was, "Commandant-Ingénieur, Chef du Service Technique au Régiment de Sapeurs-Pompiers de Paris" (chief of the Paris Fire Department). Commandant Vanginot is well qualified to make the comparison he does in this article, having spent considerable time in the United States studying fire departments. He is the author of a voluminous work on the fires and fire departments of America: "Le Service D'Incendie aux États-Unis et à Paris" published in 1923. —ED.

against fire to cope with the great increase in fire hazards incident to the recent, and somewhat sudden, industrial expansion in Europe.

New factories and large commercial establishments have been erected rapidly since the war. In this, American methods of construction have been employed because they adapt themselves to this rapid building.

Building Construction.

American building codes clearly define fire-resistive construction and indicate exactly where it must be employed. The composition and quality of materials which go into such construction is precisely indicated. In England and in Germany one occasionally finds similar codes which are, however, much less complete. In France up to now practically no such codes have appeared. Individuals do not seem to be interested in following safe building practices for their own good and the insurance companies appear to be totally uninterested in the question. In America nearly all the important cities have rules definitely allotting the mercantile enterprises, industrial establishments and dwellings to certain districts of the city and providing detailed rules to protect these districts from fire. In France these valuable administrative precautions do not exist. However, roofs of thatch or shingles have disappeared here, while in America the shingle roof remains a formidable hazard in many residential districts. (Shingles are still used in Switzerland.)

Certain elementary regulations, common requirements of many American building codes, such as requiring a certain size and number of stairways, do not exist at all in France and this standard is very rare in Europe. The commercial buildings of New York exceeding 85 ft. in height must be provided with an enclosed fire-resistive stairway. In Paris there is nothing analogous to this, not even two stairways being required. In France, establishments considered to be dangerous are covered by a special law issued by decree of the Minister of Commerce and Industry, but fire prevention measures, details of construction and means of defense against fire are not the object of any detail, so that except in certain large cities where the fire fighters and architects are well organized, supervision of details of construction or fire prevention is somewhat hit or miss.

Theatre Construction.

By contrast, the construction of theatres and motion picture houses is carefully studied in Europe. The police regulations actually in force in Paris are quite comprehensive from the point of view of construction and have just been revised. Unfortunately the size of the exits required is insufficient (31½ inches per 100 persons), and approximately half that required in New York City, for example. Furthermore, there is a practice of using portable bracket seats in aisles which is not only allowed

but even encouraged. Although the author in the exercise of his official functions has maintained a vigorous campaign against the dangerous use of these seats, administrative inertia joined with powerful influences have prevented him from securing the abandonment of this practice. The bracket seat is apparently a sacred object in Paris and its use has spread, for in the new halls it is provided with a back which is attached to the neighboring permanent seat, diminishing the width of an already narrow aisle by 5 centimeters (2 inches), when not in use. When these seats are in use on both sides of the aisle there is hardly room for one person to squeeze between them. For one, the city of Lyons in its new regulations due to the energetic efforts of the Chief of the Fire Brigade has prohibited the bracket seat.

The stage of theatres is generally in France protected by "grand secours" sprinklers operated by opening a special valve in case of fire. Water from a standpipe of sufficient diameter and 40 millimeter (approximately 1½ inches) branches floods the stage as from a watering pot. While this device requires manual operation, it is more powerful than automatic sprinklers and has demonstrated its value. The single curtain of theatres is of sheet iron and in the case of theatres recently built is covered in case of fire by a water curtain. Standpipes and hose sets of a somewhat smaller diameter than those customarily used in America are installed in all theatres. In resumé the American theatre, with exits approximately 1½ times wider per hundred persons, presents greater safety to the public than the French theatre because it can be more rapidly emptied. On the other hand, the French theatre is more powerfully equipped with fire protection.

Height of Buildings.

The author admires American sky-scrapers, appreciating their advantages, and deplores the attitude of many of his compatriots who oppose the construction in the larger cities of buildings of *from 15 to 20 stories only* which would be particularly adapted for the business such as in the vicinity of La Bourse, in Paris. In Paris, height of the building facade is limited to 20 meters (about 65 ft.), with a reduction in height, depending upon the width of the street, when the street is less than 20 meters wide. Buildings may be higher than this provided that above 20 meters there is a setback so that the profile will fall within a line extending back at an angle of 45 degrees. This limiting 45 degree line is connected to the vertical line of the facade by the arc of a circle that has a radius determined by the width of the street. In most American cities the rule, if not so elegant, is much simpler, only the number of stories and the total height ordinarily being fixed.

Fire-resistive construction has made such progress that if it is conscientiously employed a sky-scraper can be made to present every possible guarantee against fire and safety for its occupants. Its weak points are its stairways, openings between floors, elevator and dumb waiter shafts. The second fire in the Equitable Building in New York City (see QUARTERLY, April 1926, Vol. 19, No. 4, page 373) emphasized the special hazard of the shafts in which the various electric cables, gas pipes, water services, pneumatic tubes, etc., are constructed. Referring to that fire, it particularly astonished the European observer that a large gas pipe had been placed in the same shaft with other pipes and that the meter was not turned off while the building was unoccupied.

Municipal Fire Protection.

One is aware of very marked differences between the organization and methods of municipal fire protection employed in Europe and in America. American fire departments present a striking superiority in strength, especially as to personnel, fire stations, and fire fighting equipment, a superiority brought about and nearly always justified by the "four" dimensions of cities to be taken care of—width, length, height, and "value." The cost of the fire protection service varies with the wealth and the hazards of the cities and a comparison is very difficult to establish. For example, in Paris, in 1925, the per capita cost of the fire fighting forces was about 4 francs,[1] while in New York it was $3.72 in 1925. To compare these costs at the present rate of exchange is of course not very indicative as the proportion would be about 4 to 90.

Permanent Fire Forces.

Permanent fire departments are general in America. They are found even in cities of as few as 10,000 population, while in Europe one scarcely finds them in cities of less than 40,000. In France a truly permanent corps of Sapeur-Pompiers exists only in cities of more than 80,000 inhabitants. The number and distribution of fire stations is much better in America than in Europe and results in greater promptness in arriving at fires. The American system of elaborate "running cards" on which are worked out in detail the response of apparatus to all fires is not employed in Europe where apparatus is moved around from fire to fire entirely on the initiative of the officers in charge. The European method is sometimes faulty due to its reliance on the human element, but it has the advantage of proportioning the response of apparatus to the importance and nature of the fire. In all countries the fire fighting equipment in use is generally adapted to the requirements of the cities and the amount of equipment is determined by the funds available.

[1]At the pre-war rate of exchange this would be about 77c.—ED.

Because of the relative infrequency of serious fires, municipal fire fighting apparatus is much less powerful in Paris than in American cities. The picture shows the Paris Fire Brigade at work on a fire in a large department store building of poor construction from a fire hazard standpoint, a type of fire common enough in America but unusual in Paris.

In America civil service examinations protect candidates against political and religious discrimination, but this method is little employed in Europe which is to be regretted. However, a sort of examination is nearly always required in Europe and physical tests must always be passed. Examinations for promotions while quite well developed in America, are not generally enough considered in Europe and unfortunately do not exist in France. The fire alarm systems installed in American cities are wonderful in spite of the lack of street telephones which are commonly used in Europe.

Fire Fighting Methods.

The methods of extinguishing fires in Europe and America present differences which are the natural result of differences of organization and economic factors. It is incontestable that the American fire department shows a tendency to get to a fire promptly, there to use a large number of men and powerful equipment even at fires of small importance. While no European fireman can reproach his comrades of the new world for getting to fires promptly, the American methods of fire fighting in the case of small fires appear to him to be exaggerated. In the author's opinion, the use of nozzles $\frac{5}{8}$ in. in diameter would be more reasonable in many cases than nozzles $\frac{3}{4}$ in. or $\frac{7}{8}$ in. and certainly so in the case of dwelling fires. In

Paris this nozzle (⅝ in.) is nearly the only size used, and except at large fires, it is very useful and by the use of several of the smaller streams the fire can be attacked at more points and the losses occasioned by water reduced. These nozzles are used with hose of 1⅜ in. to 1¾ in. in diameter, itself easy to handle. The hose is usually split by a Y which permits having two lines from a 2¾ in. to 3 in. hose and a single man is required to hold ⅝ in. hose streams. In Paris a company of 9 men can easily handle 4 lines and in very quick time. In America there now seems to be an increasing tendency to use smaller lines at minor fires.

American fire commissioners and fire chiefs appear to have ample powers. In France the powers of the mayors and prefects would be sufficient if they were judiciously employed, but these positions are rarely filled with men competent or qualified to handle questions of fire prevention or control.

The water service, one of the principal elements of fire defense in America, is very generally developed because of the possibility of securing water from large territories, of the wealth of the cities, and above all, for the great demand for cleanliness and comfort. In Europe the question is incomparably more difficult to handle due to the lack of sources of water supply, lack of reservoirs, and to the lack of money. Save for exceptions in certain of the hill districts cities are less well provided for in this respect than American cities. High pressure systems are unknown in Europe but the normal pressure in most cities is sufficient for fire service. In some it is very high. At Geneva and Lausanne, Switzerland, it reaches 12 to 13 atmospheres (175-190 lbs. per sq. in.).

While automatic sprinklers are quite common in America, in Europe, England excepted, this equipment is comparatively rare. Nevertheless, their adoption is making rapid progress.

One of the marked advantages of America are the organizations devoted to studying the control of fire and carrying on education about it. In Europe there does not exist any organization comparable to the National Fire Protection Association or the National Board of Fire Underwriters. The publications prepared and promulgated by these two organizations, including fire protection regulations, advice, periodical bulletins, etc., I consider to be of the highest order. They do not have their equivalent in any other country. The elaborate regulations are models for adoption in their entirety.

Both Americans and Europeans can learn much in studying each other's methods of preventing and controlling fires. With the best experience of each the success of the attack upon fire can be increased.

Four Women Died Here.

Courtesy Boston *Traveler*.

An expensive residence on Bay State Road, Boston. Brick and stone walls but wooden interior construction, only one stairway, open for the spread of fire. Fire started in the basement from an electric iron left in circuit, or defective electric wiring (exact cause not officially determined). Four women burned to death at 3 A. M., June 21, 1927.

"Smoke Eaters" or Cellar Ventilators.

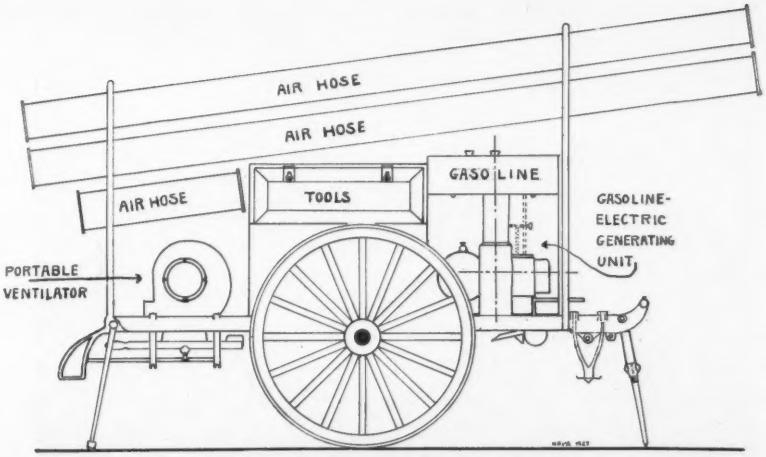
Fire departments have for some time recognized that a device which would clear cellars of smoke to make them accessible would be valuable, but apparently few attempts to develop such apparatus have been made in this country. The fire departments of three American cities, Minnneapolis, Minn., New Bedford, Mass., and Grand Rapids, Mich., have, however, recently put in operation cellar ventilating devices.

A portable "hydraulic" cellar ventilator has been in use in Paris, France, for over 30 years. The ventilator is simply a small water motor driving a blower. The apparatus weighs about 50 pounds and each pumping engine of the Paris Fire Department is equipped with one of these devices. Water is delivered to the water motor at a pressure of at least 30 lbs. per sq. in. through the hose connection, this motor driving the blower rotor which is mounted on the same shaft. This blower can supply air to a basement or cellar at the rate of 25 cu. ft. per min. when making 1500 revolutions per minute. Reinforced canvass hose is used to blow the air into the cellar to be ventilated. Apparently this device is not arranged to "suck" air as well as blow it.

Five years ago the Paris Fire Department put into operation some larger electrically driven ventilators which could be operated both to draw smoke from a cellar and to blow fresh air into it. This apparatus is intended to supplement the hydraulic ventilators in serious fires in cellars or sub-cellars. It is held at fire department headquarters and sent to fires on call. It will discharge about 1600 cu. ft. per min. through 100 ft. of hose approximately 8¾ in. in diameter (220 mm.) and about 1200 cu. ft. per min. through 200 ft. of this hose.

During the past year Chief C. W. Ringer of the Minneapolis Fire Department built one of the first, if not the first, device of this character to be used by an American fire department. His official term for the apparatus there is a "smoke extractor." It is a large blower driven by the motor of an automobile truck. A flexible metal intake pipe is used. Chief Ringer reports that with this machine he finds it possible for his men to follow up a fire from the opposite side of the building and get at it, whereas without this device removing the smoke it would be difficult to locate the fire even by firemen in smoke masks. He says that although it doesn't accomplish everything that they might hope, it is a great help. He reports that it is especially valuable for clearing rooms of ammonia gas.

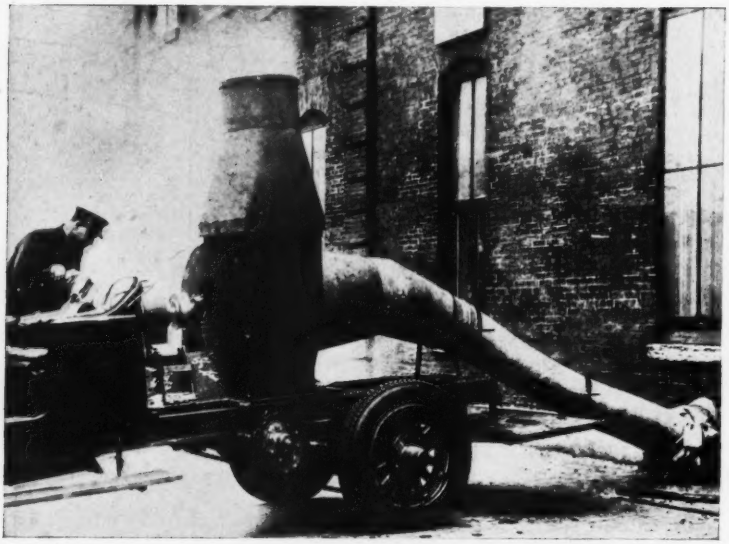
Following close on the footsteps of Chief Ringer came the development of a portable device by Chief E. F. Dahill of New Bedford, Mass.



Above, an outline drawing of the portable electric blower equipment used in Paris, France. All pumping engines of the Paris Fire Brigade carry small blowers driven by water motors and this device, of much larger capacity, is used to supplement them. It consists of an electric generator outfit mounted on a two-wheeled truck which may be rolled to any convenient point. A blower driven by an electric motor, together on a base with handles, is located on the rear platform from which it can be easily carried close to a fire. The whole apparatus is carried on the automobile shown in the lower picture. Note the "tracks" on which the apparatus is rolled off and on this carrier.

His apparatus is quite similar in principle to the portables in use for so long in Paris, but differs in that it is designed to suck the smoke out of the building rather than to feed fresh air to it as does the Paris apparatus. Its intake pipe is of sheet iron and adjustable.

The device consists of a water motor driving a 30 in. fan which draws smoke through a 12 in. pipe. The water motor develops about 2 H.P.

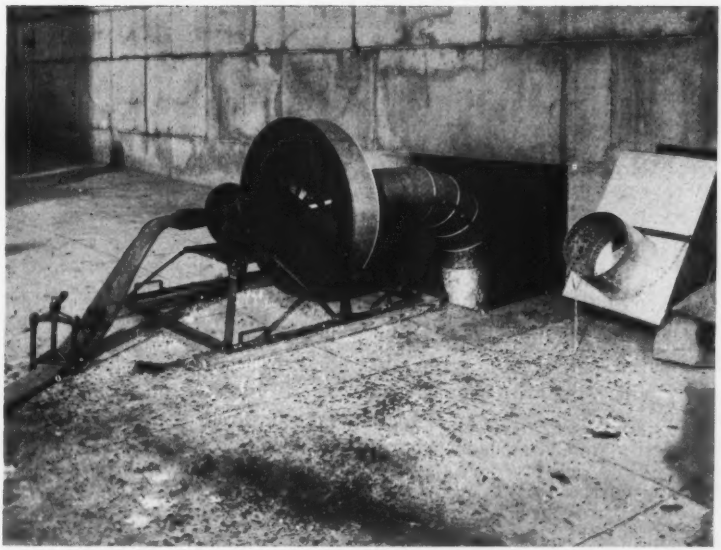


P. & A.

The "smoke extractor" designed by Chief C. W. Ringer of Minneapolis, operating on a fire in a basement. It consists of a large blower driven by the tractor which carries it around. Chief Ringer reports that it is especially helpful in clearing rooms of ammonia gas.

Courtesy *The Fire Plug.*

Grand Rapids "smoke sucker" in action. It consists of a large gasoline driven blower.



A portable "smoke-eater" designed by Chief E. F. Dahill of New Bedford, Mass. A hose stream runs a water motor which drives the fan, the water discharging on the fan, keeping it cool in case the device sucks fire as well as smoke.

under 80 to 100 lbs. water pressure. Chief Dahill reports that he has used it successfully at fires where the smoke was dense in cellars and in one case was able to enter the cellar with a hose line and locate the seat of the fire after operating the fan for only three minutes.

The Grand Rapids apparatus consists of a blower with a capacity of about 5,000 cu. ft. per min. mounted on the chassis of a tractor. It is driven by a four cylinder automobile engine using a chain drive. This combination being short, it can easily be put in position and by carrying extra lengths of piping can reach any opening in the lower portions of a building, according to Assistant Fire Marshal Fred Higgins. The suction pipe is 16 in. in diameter. In a fire in a retail furniture store in April the fire department found the sub-basement fire so far advanced that it was impossible to enter the building. This equipment was placed in an alley at the rear and the intake pipe was inserted in a basement window. Almost instantaneous results were reported, it becoming possible for men to work in openings in which they could not stay when the machine was not running.

While these devices may not be fully perfected, the experiences of these three cities indicate that they have decided value. Their primary usefulness is in speeding up the process of ventilating the cellar or basement so as to permit locating and approaching the fire.

Fire Fighting in Oil Refineries.

By Frank A. Epps (Member N.F.P.A.).

Manufacturing Department, Tide Water Oil Company.

Modern fire fighting in oil refineries begins before the fire occurs. Most of the larger oil companies and many of the smaller ones maintain continual fire inspection and prevention service. The instances are rare when fire attacks oil storage and handling equipment of modern design. Most oil fires are directly traceable to the use of construction which today is known to be hazardous. For plants built in accordance with recognized good practice, the fire frequency is exceedingly low. For plants that have in addition suitable appliances for handling oil fires, a trained fire brigade and good plant maintenance, the fire risk becomes equal to the preferred class of industrial risk.

About two-thirds of the total fire loss sustained by oil properties consists of the destruction of oil tanks and their contents. Tank protection, therefore, is the principal item towards which the oil refiner must direct his attention, in order to safeguard his plant. Lightning is the cause of approximately 55% of all tank fires. Ignition resulting from exposure to fires that have originated in other structures is the direct cause of 33% of the tank fires and the remaining 12% are ignited in an unknown manner; careless operation and static electricity probably being the principal causes of fires in this classification. Of the tanks ignited by lightning, it is of interest to note that approximately 93% of them are not gas-tight. Most of them are equipped with wooden roofs. A detailed analysis of the fire records of the all-steel gas-tight tanks which were ignited during the period 1915-1925 gives evidence of unprotected vent openings. The fire records also indicate that tanks of this construction most frequently go through extremely severe conditions of fire exposure without ignition. It is evident, therefore, that the installation of all-steel gas-tight tanks, plus their proper maintenance, practically eliminates the bulk of the fire danger.

Of all the tanks lost by fire in the period 1915-1925, 58% contained crude petroleum, 20% gasoline, 17% kerosene and like oils, 3% fuel oil and 2% miscellaneous oils. Thus, the majority of oil tanks that burn contain crude oil. This is to be expected because of the fact that fire danger and wooden tank roofs are synonymous and such tanks are used principally for crude oil.

From a paper presented before the American Society of Mechanical Engineers.

The annual frequency of fires per 1,000 tanks during the ten year period 1915-1925 was as follows, showing the relative safety of the steel roofed tank:

Contents	Wooden Roofed Tanks	Steel Roofs Tanks
Gasoline	17.9	0.26
Kerosene	15.2	0.28
Crudes	4.15	0.64
Fuel Oil	1.44	0.45

In order to prevent fires in tanks, the following are the principal considerations to be borne in mind:

Proper Construction and Arrangement of Tanks.

Tanks should be set upon firm foundations, and be constructed of open hearth steel equivalent to Structural Grade "A" as specified by the American Society for Testing Materials. Vertical tanks should be designed for a factor of safety of not less than 2.5 based on the tank being filled with water.

All openings in the tank roof, such as explosion hatches, manholes, etc., should be securely gas-tight. Venting connections for tanks containing crude oil, gasoline and other volatiles should preferably be of the sealed type and should have ample capacity to relieve any pressure or vacuum which can be developed within the tank under the most abnormal conditions of pumping out and simultaneous cooling from a shower on a hot day. Such vents should be equipped with suitable flame arresters.

Where wooden roofed tanks are employed very careful consideration should be given to the advisability of replacing them with steel roofs. Where this cannot be done, the wooden roof should be placed and kept in excellent repair, and an overhead system or network of grounded conductors should be supplied and connected to grounded metal towers located at a suitable distance away from the tank or tanks protected.

Fire walls or dikes should always be provided around crude oil tanks and should be:

(a) Of a capacity equal to that of the tank surrounded, unless adequate drainage to a sump of like capacity is provided.

(b) Located not nearer to the shell of any of the enclosed tanks than the diameter of the largest tank enclosed, and in any case not less than 50 feet.

(c) Provided with a suitable coping projecting inward to turn back boil-overs.

The construction and function of the coping referred to, was described very completely in a paper presented by Mr. H. H. Hall of the Standard Oil Company of California to the American Society of Civil Engineers in 1925.

For other than crude tanks, fire walls are so seldom required during actual fires that their construction is unwarranted except under conditions

of an unusual nature wherein the exposure of large values justifies extraordinary measures.

A ground connection of some kind is necessary. However, the earth under the bottom of most tanks is usually moist and is a sufficient ground even in exceptionally dry regions. In addition, the pipe lines connected to the tanks are usually embedded in moist earth at a point not far from the tanks. However, for tanks resting on concrete slabs and connected to an above ground system of piping, an electrical ground is essential. This also applies to tanks resting on cinders, wood or other insulating foundations.

Fire Protection.

As before noted, the probability of fire in all-steel gas-tight tanks is remote, and except in cases where large values are involved or where other considerations warrant a considerable investment in fire protection equipment, it should not be necessary to make any special provision for fire protection. Proper tank construction and proper maintenance provide in themselves very complete protection.

However, in large plants, where fires originating in other structures must be handled, it is customary to provide both steam and foam protection for the tankage. The adequacy of steam installations as they are designed and installed today is very questionable as was developed in a paper read by Mr. G. O. Wilson, in January 1926, before the American Petroleum Institute's Convention at Los Angeles. (See April, 1926, QUARTERLY, Vol. 19, No. 4, page 330.)

The only effective fire extinguishing agent for oil tank fires is foam.[1] Where properly installed and maintained such fire extinguishing systems will always give a good account of themselves. The use of foam in this country is comparatively recent, the entire development being only about 12 years old. Nevertheless, today there are very few modern refineries which do not have foam systems. Almost without exception, where they have been installed in accordance with the proper standards of design, they have operated successfully and have saved much property that would have otherwise been lost.

Several other types of tank fire extinguishing equipments have been and are being developed; these utilize water sprays, carbon tetrachloride and carbon dioxide. As applied to oil tanks, these equipments are still in the experimental stage and have only a record of test fires to their credit.

Operation.

Under no circumstances should an excavation be made under a tank in order to repair a leak in the bottom, unless the tank has been entirely

[1]The limitations of foam systems and the development of methods which increased the effectiveness of foam on oil tank fires, were described in the QUARTERLY for April, 1927 (Vol. 20, No. 4, page 356), "Oil Tank Fire Tests," by H. H. Hall.—ED.

emptied. Failure to observe this precaution has resulted in failure of the bottom plate and loss of contents of tank, not to mention narrow escape from drowning on the part of the men around such excavations.

Gauge poles should be fitted with brass hinges and shoes instead of iron so as to eliminate possibility of mechanical sparks. Gauging tapes for the same reason should be fitted with brass plumb-bobs. The gauger should be instructed regarding the necessity of keeping all hatches closed and violation of this rule should be sufficient reason for discharge.

Before making repairs on any tank a "gas free" certificate should be obtained from the laboratory. The use of electric extension lights should be prohibited in tanks that have previously contained volatiles, unless the most rigid procedure has been followed in cleaning and "gas-freeing" the tank.

In the relatively few cases of ignition of all-steel gas-tight tanks, it has been observed that such ignition resulted directly because of some defect in equipment which rendered the tank sub-standard at the time of ignition. This is a fact of prime importance emphasizing as it does the necessity for continual tank maintenance. Every oil company should, if this is not already its practice, institute at once careful and periodical inspection of such equipment. Records of these inspections should be kept and the defects found should be promptly remedied.

Distillation Equipment.

Next to oil tanks, the greatest fire risk in oil refineries is to be found in the distillation equipment. Fire prevention around such equipment can be summed up in one sentence: Careful operation and first-class upkeep.

Most frequently, fires occurring in the distillation process are caused by small oil or vapor leaks. They are usually put out with hand extinguishers, steam jets, water hose or by pumping out the still with negligible loss. Occasionally, however, something lets go, a still bottom splits, a high pressure drum explodes, or an oil line breaks, and a big fire is under way. In order to handle fires of this type, the distillation unit should be designed and installed with the following three points in view:

1. Provision of facilities for the rapid removal of the oil in the burning still and in nearby stills.
2. Provision of facilities for confining the spread of the fire.
3. Provision of adequate fire extinguishing equipment.

Dealing with these in the order named, it is evident that one of the simplest and most effective ways of handling a serious still fire is quickly to pump out the burning still and those which are menaced. Therefore, the importance as a fire protection measure of having large pumps for this purpose and large pumping out lines is apparent. It is essential, however, that all valves in the pumping out line shall be equipped with remote

controls, so that they can be operated safely and surely—usually from in back of the condensers. Serious consequences may result if during the excitement the still is pumped out without having top steam turned on. It is quite probable that failure to observe this point has been responsible for many of the still explosions and the resultant loss of life which have occurred during such fires. Since the steam line is so important, its valve control should be just as accessible as the pumping out valve control, and its installation should be reasonably secure against injury.

In order to limit fire spread, it is important to provide, as far as practical, fire walls around every battery of stills. Frequently, the near walls supporting the condenser boxes may be used as part of this surrounding fire wall. It is further desirable to break up the fire areas in and around the units of any battery, so that a flood of hot oil pouring from a break will endanger as few adjoining stills as possible. Catch basins and sewers should be connected to the areas so enclosed and such connections should drain to remotely located separator ponds.

It frequently happens that small fires assume serious proportions because oil and vapor lines are improperly supported. The collapse of their supporting members and consequent breakage of lines or fittings permits the contents of these lines to drain stills and add fuel to the blaze. It is of prime importance, therefore, that crude charging lines, flow lines, vapor and reflux lines, fractionating towers and such equipment be supported by structural members properly insulated.

Fire protection equipment around stills usually consists of first aid fire extinguishing devices, as 2½ gallon foam extinguishers and 40 gallon foam chemical engines, steam hose fitted with long extension nozzles, water hydrants and hose, and foam hydrants and hose.

Foam Systems—Dry Chemical Type.

Foam systems are of two general types, namely, the dry-chemical portable type and the stored-liquid stationary type. The former is a very recent development and its limitations have not yet been fully determined. In general, this type of installation seems to fill the need for foam equipment intermediate both in capacity and in cost between the portable wheeled foam fire extinguishers and the stored-liquid stationary type of installation.

The dry-chemical equipment consists essentially of a so-called "foam generator" which weighs about 110 pounds and requires from 60 to 100 pounds of water pressure for its successful operation. A line of 2½ inch hose is extended from a water hydrant to the generator and 50 to 150 feet of hose of the same size connects the discharge of the generator to the

nozzle. The generator itself is essentially a water ejector, which is mounted on a portable frame and equipped with a funnel or hopper. The vacuum surrounding the constricted water stream in the ejector draws the dry-chemical contained in the hopper into the water. The component chemicals in the presence of water immediately dissolve and re-act, so that a stream of the resulting product—foam—issues from the nozzle. The dry-chemical powder consists of sodium bicarbonate, ground aluminum sulphate, powdered foaming extract and a small percentage of inert clay, all ground to a fine mesh, thoroughly mixed and packed in forty pound cans, hermetically sealed. These cans are supplied with quickly detachable covers, and in case of fire the contents are poured into the hopper of the generator at the rate of about two cans per minute.

The effectiveness of this type of equipment is measured by the following:

1. An adequate supply of water at the required pressure.
2. The quantity of dry chemical in storage. Obviously this device can supply a foam stream as long as the water supply and the supply of dry chemicals last.
3. The auxiliary connections which are available to assist in discharging the entire output directly on the seat of the fire.

In the writer's opinion, the limit for one generator under good conditions is about 500-700 square feet of burning oil surface. On a fire much larger than this, the foam will probably be consumed as rapidly as it is applied. The minimum quantity of dry powder in storage should be sufficient to keep all generators in operation for a period of about one hour.

Foam Systems—Stored Liquid Type.

This type of foam installation provides storage containers or tanks for two chemical solutions. The remaining part of the installation consists of a pump, pipe lines and devices for mixing the solutions and applying the foam to the fire. In case of fire, the two foam chemical solutions are pumped separately in equal volumes through a twin system of pipe lines to specially designed mixing chambers mounted on the oil tanks, or to portable devices which are provided for emergencies.

The two foam chemical solutions "A" and "B" are made up in the following proportions:

	Percentage by Weight	Contents of one gallon of Solution
SOLUTION "A"		
Aluminum sulphate	13%	1.163 lbs.
Water	87%	0.935 gals.
SOLUTION "B"		
Sodium bicarbonate	8%	0.708 lbs.
Liquid foaming extract	3%	0.265 lbs.
Water	89%	0.946 gals.

When these two solutions are mixed, the following chemical reaction takes place: $6NaHCO_3 + Al_2(SO_4)_3 = 3Na_2SO_4 + 6CO_2 + 2Al(OH)_3$. It will be noted that the liquid foaming extract plays no part in the chemical reaction. When the sodium bicarbonate and aluminum sulphate combine, there is a rapid effervescence of the mixed liquids resulting from the formation of the carbon dioxide gas. Simultaneously the formation of gelatinous aluminum hydrate reduces the surface tension of the liquid to the point that bubbles are quickly formed. The presence of the foam stabilizer makes these bubbles extremely tough, durable and tenacious. The two solutions are of such concentration that when equal quantities of each are mixed, they produce approximately eight to ten times their combined volume in foam. This foam has the property of floating on liquid surfaces, adhering to walls, ceilings, etc., and in fact coating any surface which can burn. Once such a surface is so coated, the fire is effectively extinguished and cannot reignite until the foam breaks down, which it does very slowly.

Actual tank fires have demonstrated that from one to two gallons of each chemical solution are required per square foot of burning oil surface before the fire is extinguished. It is customary to provide a factor of safety in the amount of chemicals which are carried on hand in liquid storage, as it is practically impossible to mix the dry chemicals rapidly enough during a fire to replenish the supply. Obviously, the several factors are as follows:

1. The area of the largest tank.
2. The area of other tanks in the immediate vicinity of the largest.
3. The total number of tanks to be protected.
4. Allowances for favorable conditions such as incombustible roof, oil of low volatility, etc.

These factors have been combined in the following empirical formula:

$$S = (5A + 3B + 2C + D) \times [1 + 0.02(N - 5)] \times (1 - R)$$

where

S = Volume (U.S. Gals.) of each chemical solution to be provided.

A = Area (sq. ft.) of oil surface of the tank having the largest exposed area.[1]

B = Area (sq. ft.) of oil surface of all tanks (not including oil tank "A") within the exposed area[1] of tank "A" and lying wholly or partially within a distance of one tank diameter[2] from tank "A".

C = Area (sq. ft.) of oil surface of all tanks (not including oil tanks "A" and "B") within the exposed area[1] of oil tank "A" and lying wholly or partially within a distance of two tank diameters[2] from oil tank "A".

[1]Exposed area is the area represented by the quadrant of a circle whose center is the center of that tank and whose radius is equal to 3½ times the diameter of that tank which yields the largest amount of solutions when calculated in accordance with the foregoing formula.

[2]Distance expressed in diameter of oil tank "A" and measured from shell (not center) of oil tank "A".

D = Area (sq. ft.) of oil surface of all tanks (not including oil tanks "A", "B" and "C") within the exposed area[1] of oil tank "A" and lying wholly or partially within a distance of three tank diameters[2] from oil tank "A".

N = Ratio of total oil surface area of all protected tanks on premises to oil surface area of oil tank "A".

R = Reduction in solution quantity depending upon conditions favorable to fire extinguishment such as low volatility of oil incombustible roof members, etc.—0 to 50%.[3]

Solution "A" is good until used unless it becomes contaminated with oil. Solution "B" is subject to slow deterioration.

It is customary to provide either two or four foam solution tanks at each installation. It is safer to have the solutions stored in four tanks than in two as repairs to one tank, renewals of solutions, etc., can be effected without putting the entire system out of commission. Tanks for the "A" solution should be lined with lead, as this solution readily attacks iron and steel.

Control valves on pipe lines should be located outside of fire walls and not less than a tank's diameter away from the tank they control. In no case should such control valves be located nearer than fifty feet to the tank protected.

In order that the foam solutions may be effectively applied to a burning tank, it is desirable, first, to produce the foam as near the fire as possible; second, to have the chemical reaction completed before the foam reaches the fire, and, third, to subject the foam to as little rough usage as possible.

So-called mixing chambers are manufactured for this purpose and are devices that are adapted for permanent installation on vertical oil tanks, so that the foam may be generated in them and discharged into the tanks over the top of the shell through an opening in the roof.

No foam installation is complete unless foam hydrants are provided and available for use at all locations where oil fires may occur. In general, they should be located not nearer than fifty feet and not further away than 250 feet from the risk which they are to protect.

Hose reels should be provided and located at strategic points around the plant. These portable reels should be equipped with twin lengths of rubber covered, rubber lined hose. The working length of hose on the

[1]See footnote (1) on preceding page. [2]See footnote (2) on preceding page.

[3]For such tanks as have roofs of all-steel construction and/or contain high flash point oils (fuel), lubricating or gas oil, wax, paraffin, tar, etc., on properties, the nature of which assures that the class of the tank contents will remain unchanged, reduce the factors by 0 to 50%, according to conditions, i.e., to the proportion of the aggregate area of tanks with roofs of all-steel construction or high flash point oils to the total area of all tanks. Where all tanks contain oil of low volatility, the maximum credit is 20%. Where all tanks are of all-steel construction, the maximum credit is 30%.

reels usually varies from 100 to 300 feet, according to the spacing of the hydrants in the property protected. The reels are housed in buildings designed for that purpose and carry suitable mixing nozzles, spanner wrenches, gaskets, hydrant wrenches, etc. In certain instances, especially in congested refineries, it may be advisable to have the hose coupled to the hydrant and stored in specially designed hose racks.

The standard size of hose adopted for foam systems is 1½ inch, rubber covered, rubber lined. However, in large refineries, where there is a sufficient crew to handle heavier hose, 2½ inch hose is frequently used. The 2½ inch lines are siamesed together into a 3½ inch mixing tube connected to a suitable play pipe. In general, not less than 30 pounds pressure and preferably 60 pounds should be available at the nozzle.

It is customary to assume that the 1½ inch line will discharge 75 gallons per minute of each solution whereas the 2½ inch line will discharge about 250 gallons per minute of each solution. The mixing nozzle sets referred to in the foregoing are of standard design and comprise the following equipment:

1½ in. units.....	1 nozzle, 2½ in. x 30 in.
	1 nozzle tip, 1⅛ in. smooth bore
	1 mixing tube, 2½ in. x 5 ft.
	1 Siamese connection, 1½ in. x 1½ in. x 2½ in.
2½ in. units.....	1 nozzle, 3½ in. x 14 in.
	1 nozzle tip, 1¾ in. smooth bore
	1 mixing tube, 3½ in. x 8 ft.
	1 Siamese connection, 2½ in. x 2½ in. x 3½ in.

There are many special applications of foam protection that have not been given space in this paper. The design of adequate foam protection for special risks is a subject in itself; however, the following are the principal items to be considered:

1. A *more than adequate* supply of foam solutions.
2. Pipes and delivery facilities large enough to put properly mixed foam on the fire *rapidly*.
3. Mechanical perfection of design of all parts—especially those handling the "A" solution.
4. Adherence to tried methods and apparatus.
5. Facilities for inspection and testing. Don't forget that the equipment may stand idle for years before it is called into service.

The fire record of the oil business is remarkably good considering the nature of the products handled, their volume and the far reaching extent of the industry. Oil fires seldom occur but when they do they may be readily segregated, controlled and extinguished when good design and adequate fire equipment are employed.

Five Tanker Fires.

By A. J. Smith.
Secretary, Marine Committee, N.F.P.A.

Since publication of accounts of fires or explosions on the tank vessels *Waring, Silvanus* and *Gulf of Venezuela* in the October 1926 QUARTERLY (Vol. 20, No. 2, page 137), some data on five more disasters of a similar nature has been obtained which permits a continuation of the previous article and brings up to date the account of outstanding tanker fires in American waters.

On June 14, 1926, at 3:15 P. M., an explosion occurred in the fore deep tank of the S.S. *Paul Shoup,* owned by the Associated Oil Company of California. The vessel went on drydock at the San Francisco plant of the Bethlehem Shipbuilding Corporation, for the purpose of cleaning and painting; and after it came dry, a few keel rivets in the way of the fore deep tank were found leaking. A dock hose was run about four feet through the sounding cap of this tank and water at sixty pounds pressure turned in preparatory to calking and welding the loose rivets from outside, but neither of these latter operations had been commenced. The tank hatches and manholes were closed, the only open connection to outside being two screened vents above deck at either side of the f'castle head. The rest of the vessel was completely cold, no power of any kind being on board.

While the deep tank was being run up, and only about three hours after the vessel came dry, a violent explosion occurred in the tank which wrecked the whole fore part of the vessel. No fire ensued, but three men who were on or under the f'castle head at the time were injured.

The *Shoup* had just completed a voyage from Port Arthur, Texas, to San Francisco via Panama Canal. Between Port Arthur and the canal (May 20, 1926) all cargo tanks had been steamed and washed down and on the way up the coast (on June 8), the chain locker and 'tweendecks over the fore deep tank had been cleaned and vented. The deep tank itself had been neither steamed nor cleaned as it was a fuel bunker. It had, however, been pumped empty on the run down to the canal.

Even a plausible explanation of the explosion is lacking, but it seems possible that a stream at sixty pounds pressure entering near the top of the tank might stir up latent gases and force them out through the vents or sounding cap where the hose entered and that at just the inopportune time, a spark of some kind was struck. The damage amounted to approximately $100,000.

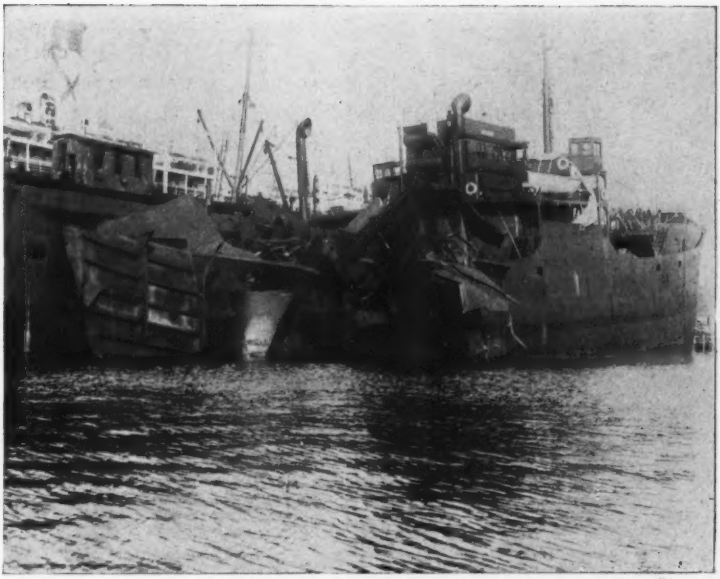
P. & A.

The fire following the collision of the Dutch tank steamer "Silvanus" and the American tanker "Thomas H. Wheeler" on the Mississippi River below New Orleans. Twenty-five members of the crew of the "Silvanus" were killed in the explosion caused by the collision.

Within the three weeks between November 19 and December 11, 1926, three other tankers blew.

On the former date, the Norwegian S.S. *Mantilla* on drydock at Sparrows Point (Baltimore) plant of the Bethlehem Shipbuilding Company had an explosion in eight of her sixteen tanks. Eighteen men were killed, about seventy injured, and extensive damage done to shore property as well as to the vessel. The account published in the January, 1927, QUARTERLY (Vol. 20, No. 3, page 281) probably is as authentic and detailed as can be obtained outside of the Norwegian Underwriters and Consular Service. The vessel was admittedly gassy, but in only for cleaning and painting. It is quite definitely established that no burners were at work, but scaling and chipping was going on on deck near the hatches. The answer to the query "How?" probably lies there.

The S.S. *Warwick* of the Union Oil Company of California fleet was the next victim. On November 30, 1926, the vessel was at the loading berth, Wilmington, Cal., taking on gasoline to a full load. At 10:07 A. M., while the deck officer was topping off No. 7 tank, an explosion occurred in the crew quarters located under the poop, and a man with clothing aflame ran forward igniting four main tanks and six summer tanks at the caps before he dropped. Four men lost their lives and several others were severely burned or injured. The poop was wrecked, but fortunately the



P. & A.

The wreckage of the tanker "Agwisun" tied up at Erie Basin, Brooklyn, following the explosion of one of its tanks which had been recently emptied of a cargo of light crude oil. Fortunately only one man was injured in the blast.

fire was confined to that portion of the vessel and to the ullage caps of the ignited tanks but did not strike below. It was extinguished by plant and city apparatus using foam. Only about $15,000 damage was done. Before the vessel began loading, all fires on board were out and filling lines properly grounded; but an electric service line from shore was connected in and lights in the crew's quarters were ordinary shore type without globes or guards; also the doors and portlights in the forward end of the crew quarters were open on to the deck. With the exception of the overflow, the accident was a repetition of the *Gulf of Venezuela* case; fumes forced out by the filling operation evidently penetrated the crew quarters through open doors and ports and a broken light or spark of unknown origin did the rest.

The last of this three weeks' trio was the AGWI Lines' tanker *Agwisun*. The vessel had arrived at New York, December 7, and discharged a cargo of light domestic crude oil to lighters off Tompkinsville, S. I., had then steamed and washed tanks, and on December 10 proceeded to Robbins Drydock, Erie Basin, for cleaning and painting bottom. This work was completed and vessel put off dock and tied up to a yard

P. & A.

Another view of the "Agwisun" showing firemen cooling the wreckage. The considerable damage done by the explosion can be seen in this picture.

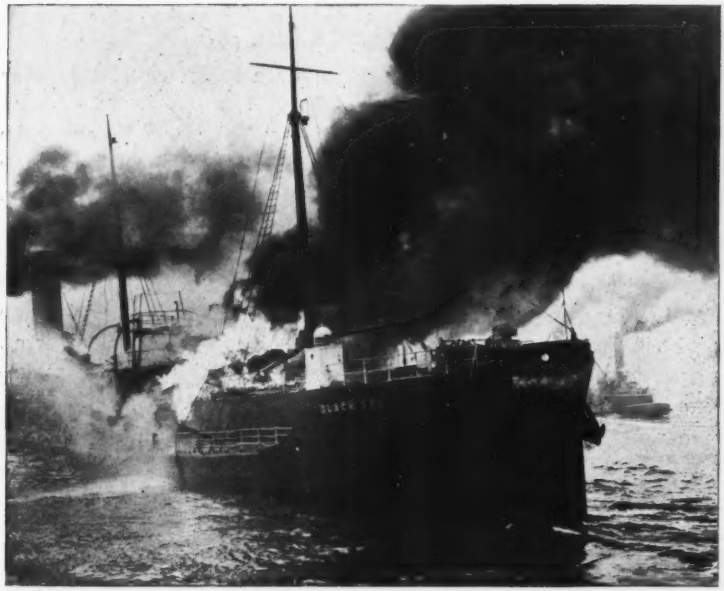
pier on December 11.

While this outside work was going on, it was also proposed to stop a small leak from No. 4 cargo tank, under the center bridge, to the pump room, which was a hold twenty feet long between tanks No. 4 and No. 5. Tank No. 4 had had a second steaming and been pronounced gas free, but work had not commenced on it. The windsails were set in the hatches. The hatches on all other tanks are said to have been closed, but ullage caps were open. Oil was being run back by gravity from tanks No. 1 and No. 2 to tank No. 5 in order to get propeller immersion on leaving next day. The whole ship, with the exception of tank No. 4, was no doubt gassy, but known to be so. This was the condition at 5:50 P. M. on the 11th, when an explosion variously stated as originating in the pump room or tank No. 5 and immediately followed by others, wrecked the whole after well of the vessel. Fire in the wrecked tanks followed, but was quickly extinguished or burned out. The cofferdam and cross bunker bulkhead aft of cargo tanks held or the fire would have been much more serious. No deaths resulted and only one man, who was coming up the gangway, was injured.

The actual cause of the explosion remains a mystery; though, as usual, rumors of chipping, hammering and smoking have been the rounds without confirmation or even good ground for credence. It is apparently another case of personal error, an unknown slip by an unknown person, and will have to be written off as such. The damage amounted to about $475,000.

The most recent and spectacular of these five disasters, though far from the most serious, was the explosion and fire on the British tanker *Black Sea*, owned by the Black Sea Shipping and Oil Co., Ltd.

The vessel was loading at Pier 5 at Bayonne, N. J., on February 23,



P. & A.

Gasoline tanks on the British tanker "Black Sea" burning after an explosion which killed three men. The boat was tied up at a Bayonne, N. J., pier, but was towed off and beached on the Brooklyn flats and the fire put out by fireboats.

1927, naphtha in forward and after tanks, kerosene in next to after tank and gasoline in the two 'midship tanks in the way of the center bridge.

An explosion occurred amidships immediately igniting the two tanks of gasoline and seriously damaging that portion of the vessel. The kerosene and naphtha tanks did not catch fire. Tugs towed the blazing ship across the bay to the Brooklyn Flats and beached her, a performance much to their credit, for at the time it appeared that the whole vessel would go and further explosions were likely. The fire was eventually extinguished by fireboats. Many thrilling rescues were performed, but three men were burned to death on board. The hull loss was about $60,000.

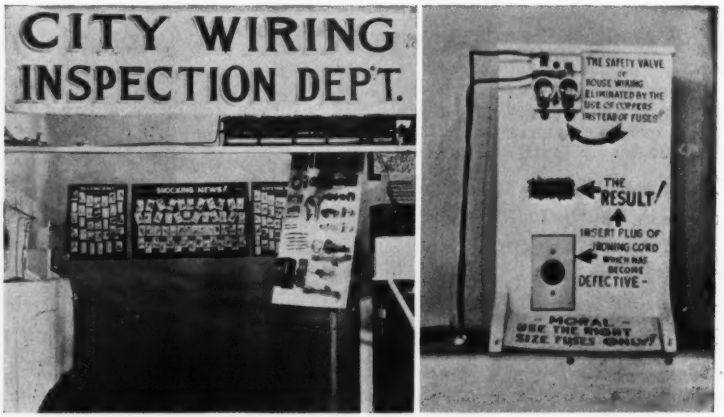
The cause of this disaster was largely structural. The vessel is a turret decker with the center bridge erection housing crew quarters and store rooms saddled over tanks Nos. 3 and 4 amidships. The turreted portion was practically an upper 'tween or shelter deck space and under the floor of the midship accommodations was an air space open to this 'tween deck directly over the cargo tanks. Such a space is easily gassed and not easily freed. The explosion took place in the port side of the

bridge erection where the engineer's stores and lavatory were located. The bodies of the three who lost their lives were found there and knowledge of the specific cause went with them; but a forbidden light of some kind is a reasonable assumption.

A peculiar phenomenon occurred after all fire was out and the pumpers were alongside lightening cargo. Three times small fires broke out in the f'castle when no person, electric light or fire was near the spot. They were easily extinguished.

This list of disasters has stirred the whole tanker and affiliated industries and a concerted and determined effort is under way to set up a standard of practice which will reduce the physical hazards to a minimum and systematically combat the ever present danger of personal error. The program of the N.F.P.A. Marine Committee on this project was outlined in the report to the recent annual meeting of the Association.

An Exhibit of Electrical Hazards.



A novel exhibit of fire hazards that develop in connection with electric wiring was arranged by Sydney L. Wilson, Wiring Inspector of Victoria, British Columbia. It occupied a booth for six days at the annual Home Products Fair in Victoria in April and was visited by some 12,000 people. The photograph above at the left shows a general view of the exhibit. The photograph at the right shows a device which was used to demonstrate graphically the hazard of bridging fuses with pennies. By inserting a defective wiring cord in the outlet, the overloaded wires could be seen to come to a white heat through the peep hole provided in the panel.

Mr. Wilson writes that his contacts with the people at the exhibit showed that nine out of ten did not know what a fuse was for and that few housewives understood the hazard of extension cords and various electrical attachments.

Venting Dust and Solvent Vapor Explosions.

By A. L. Brown, Engineer in Charge.
Factory Mutual Laboratories (Member N.F.P.A.)

Dust explosions have occurred over a period of many years. Records of explosions in flour mills cover more than fifty years.

Following several severe explosions in coal mines about twenty years ago, the Technological Branch of the U. S. Geological Survey started an investigation of dust explosions. This branch of the Geological Survey later became the U. S. Bureau of Mines. Recently that phase of the work dealing with industrial plant dust explosions has been continued by the Bureau of Chemistry of the U. S. Department of Agriculture.

A complete record of this work up to 1922 is given in the book, "Dust Explosions," written by D. J. Price and H. H. Brown of the Bureau of Chemistry, published by the N.F.P.A., and makes a valuable and complete reference book.

The Federal Bureaus of Mines and Chemistry were instrumental in developing the Frazer-Clement explosion apparatus in which can be made, on a small scale, tests to show the relative explosiveness of different samples of dust. The Factory Mutual Laboratories built a slightly altered form of this apparatus and found it very valuable in its work on venting dust explosions.

Although the behavior of an explosive mixture of dust and air is somewhat different from that of a mixture of explosive gas and air, the practical results and the extent of the damage are comparable. The severity of an explosion depends upon the amount of heat which is liberated and the rapidity with which the combustion takes place. With the more flammable dusts, the explosion pressure generated may be greater than that obtainable with flammable gases such as gasoline vapor, acetylene or hydrogen. This is because the heat of combustion of a flammable solid is usually much greater than that of a corresponding volume of gas. Due to the small volume of dust, the room or explosion chamber will have a larger volume of oxygen than where part of the air has been displaced by the gas. The rate of flame propagation in a mixture of dust and air is relatively slow as compared with that which may occur with a gas-air mixture. As a result dust explosions are less violent.

Many factors influence the explosiveness of a dust. All materials which are combustible are not necessarily explosive. Hard coal, charcoal

This article is based on the results of tests by the Inspection Department, Associated Factory Mutual Fire Insurance Companies (Member N.F.P.A.).

or coke dust do not readily propagate an explosion, while soft coal, resins, grain or hard rubber may be very explosive. Aluminum powder when finely ground is a very dangerous dust, although this metal may not usually be considered combustible.

With any given material, the severity of an explosion is influenced by the fineness of the dust particles. In general, the finer the dust, the greater the explosion hazard. In a few exceptional cases, the physical character of the material or atmospheric conditions may cause extremely fine particles to clump together, giving the effect of a coarser dust.

Many dusts fine enough to pass a 200 mesh screen are explosive. A dust which appears quite coarse may have sufficient fine particles to be dangerous. Ordinary sawdust under favorable conditions of dispersion in air has been known to burn with explosive violence. Wherever flammable or readily combustible dusts can collect it can be considered that an explosion hazard exists.

Elimination of the dust or means for preventing its collection in amounts sufficient to cause an explosion is the only sure way to prevent a dust explosion. Elimination may be impracticable but good housekeeping is always possible. In many industrial processes involving grinding or pulverizing, hazardous conditions can be localized by enclosing machinery, using suction on the equipment to prevent the escape of dust into the building.

Elimination of all possible sources of ignition is a second preventive measure. With certain manufacturing processes, this cannot be accomplished with certainty.

A third possibility is to make the dust relatively incombustible by mixing with it a totally incombustible dust or by reducing the oxygen content of the air to a point where it will not support combustion. A well-known example of adding an inert dust is in the so-called "rock-dusting" of mines, where a quantity of limestone dust or a similar product is distributed. The use of inert gas for the prevention of a dust explosion was first reported in connection with the grinding of sulphur where it was adopted about 1909. In 1914, the U. S. Bureau of Chemistry designed experimental equipment in which carbon dioxide gas was circulated inside of grain grinding equipment. Following this many experiments have been made using inert gas obtained as a flue gas from furnaces. In general, the reduction in oxygen necessary is influenced greatly by the nature of the dust. In flour or the usual grain elevator dust, a reduction from the normal 21% to 15% will generally be sufficient to prevent an explosion. With other dusts, a reduction to 12% or even 8% may be necessary. The action of various explosive materials cannot be predicted and the necessary safeguards should be based upon actual test results.

Courtesy *Factory Mutual Record.*

An interior view of the dust explosions test house showing the automatic windows, the special mechanism holding the windows open after automatic operation.

In spite of preventive measures, there is always the possibility that their effectiveness will be impaired and steps should be taken to minimize the damage caused by an explosion if one occurs. The relation of prevention and control is similar to that presented by the fire hazard. The prevention is of first importance but control is essential.

Doubtless fire was at one time considered an uncontrollable hazard. But fire protection engineering has shown that the fire risk is controllable, thanks largely to the automatic sprinkler. In like manner, it now seems possible to reduce the dust explosion risk, largely through a system of automatic venting devised to prevent the building damage which usually results.

Explosions are the result of an accumulation of pressure from the heated gases produced by the almost instantaneous combustion of the fine dust particles. Since this pressure confined inside a building tends to force the structure apart in seeking relief, the problem is then to relieve the pressure before it accumulates to the danger point. One method of accomplishing this is to arrange doors or windows to swing outward automatically and vent the pressure as soon as it develops.

By making tests on a practical scale, the Factory Mutual Laboratories have shown that this method of protecting against damage is feasible.

Preliminary tests were made in a strongly constructed wooden box, 6 ft. by 8 ft. by 8 ft. high. Test explosions were later made in a one-story

Courtesy *Factory Mutual Record.*

The test house at the Everett testing station of the Factory Mutual Laboratories in which dust explosions on a practical scale were reproduced. A dust explosion is shown venting itself through doors and windows arranged to swing outward automatically, doing no harm to the structure, which is of corrugated iron on a steel frame, 40 x 30 feet in size.

corrugated-iron steel-frame building, 40 ft. long by 30 ft. wide. In this case the existing windows were arranged with hinges at the top and the doors held closed by weights and pulleys. The interior of the large building was repeatedly filled with a dust cloud which was ignited by an electric resistance coil. The resulting explosions would have destroyed an ordinary building with rigid windows and doors tightly closed, but with the automatic venting devices the pressure was immediately relieved and no damage to the building resulted. The specially designed window sash, hinged at the top and arranged to remain open or to close again after the pressure is relieved, is now on the market. The effectiveness of this form of protection was amply demonstrated by the tests and also by an explosion which actually occurred in Montreal, in a grain elevator.[1] The ordinary windows in an old part of the building were forced out of the wall, while explosion-venting windows in a new adjoining portion opened without damage.

In the tests, a vent area of one foot for every fifty cubic feet of building volume was found sufficient to vent safely any organic dust explosions that were produced. The work also demonstrated that the velocity of propagation of dust explosions is slow enough so that the moderate inertia of the venting device can be overcome before serious pressures can build up.

Hinged automatic vents were found superior to even light layers of

[1]See QUARTERLY, January 1925 (Vol. 18, No. 3, page 293).

Courtesy *Factory Mutual Record.*

A violent explosion in the test compartment charged with a vapor mixture containing about 16 per cent acetone by weight and 8 per cent by volume. Note the bricks thrown into the air from the hinged cover of an L-shaped vent on the far side of the compartment.

asbestos paper fastened only at the edges. The speed of an explosion apparently increases rapidly with the pressure so that the slight strength of such paper will permit a building up of pressure and result in a much more violent explosion. Self-closing as well as self-opening vents are desirable, as thus some portion of the inert atmosphere produced by the explosion can be retained and will prevent rapid burning of any combustible material remaining in the enclosure.

Methods for preventing damage from dust explosions can also be applied to processes involving flammable gases or vapors. Ample ventilation to prevent the formation of an explosive mixture should be provided wherever possible, and sources of ignition should be eliminated. Dilution of flammable vapors with inert gas will be beneficial where practical. Provisions for venting explosion pressures also should be provided in case preventive measures are ineffective.

Considering the greater speed and violence of vapor explosions, which may be of the nature of a detonation, there was the question as to whether or not automatic venting would relieve destructive pressures as effectively as for dust explosions.

It was to determine the practicability of venting vapor explosions that further tests were undertaken by the Factory Mutual Laboratories. Vapor-air mixtures of various hazardous liquids at different concentrations were

exploded in a specially constructed test chamber equipped with vents, the effectiveness of which were to be noted. The chamber itself was a compartment of heavy wooden construction, lined with tin and strongly reinforced with timbers and tie-rods. There were three vents, one a swing door, one a swing window, and one an L-shaped duct with hinged cover (see illustration). A weighed amount of the liquid to be tested was forced by compressed air through a copper coil immersed in a heated oil bath. This apparatus vaporized the liquid, and the vapor was then introduced into the chamber through a series of spray nozzles, which atomized any liquid which may not have been properly vaporized. A spark plug directly in the center of the enclosure furnished the ignition.

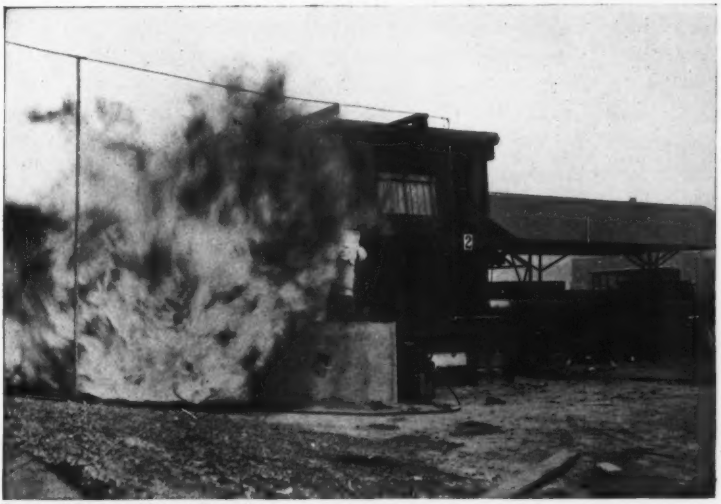
The vapors of a number of typical flammable liquids were tested, most of them at the request of, and in collaboration with, factory managers who desired definite information in order that the explosion hazard of certain industrial processes might be recognized and safeguarded. These liquids included acetone, wood alcohol, benzol, ethyl and butyl acetate, butyl alcohol, toluol, xylol, carbon bisulphide and gasoline. Altogether a hundred or more vapor explosions were reproduced.

In these test explosions the pressures produced were relieved harmlessly to the outside atmosphere with no damage to the structure itself. The three vents had a total area of one square foot for every ten cubic feet of volume, and this ratio of one to ten is therefore considered effective for relieving the ordinary vapor explosion. A ratio of one to fifty, it will be recalled, was previously determined as the proper ratio for dust explosions.

Venting, if successful, greatly reduces property damage, but does not safeguard against possible injury or burning of workmen. This is an important reason for making every effort to prevent the explosion, which is the only way to make life surely safe.

Vents for enclosures around manufacturing equipment where an explosion hazard exists should lead directly outdoors, either through the roof or side wall. They should be as short as possible, and preferably straight, although these tests showed that an L-shaped vent, when required for special conditions, is also effective. Vents which open into the room will relieve pressures within the enclosure satisfactorily, but the explosion wave may then cause loss of life or property damage in the roof itself. This explosion wave can be relieved by swinging windows in an outside wall.

Since the tests were made, reports have been received of explosions in vented dryers where flammable solvents were used. Damage to the dryers was prevented by automatic vents but the buildings were injured by the



Courtesy *Factory Mutual Record.*

An explosion of benzol vapors where the mixture was too rich for perfect combustion. Only a mild explosion resulted in the test chamber. The benzol vapors vented through the swinging door, ignited, and flashed as shown.

pressure wave as they did not have hinged windows or other means for relieving internal pressure.

Although no direct measurement of the force of the test explosions was made, a good idea of the relative intensity of explosions of various vapors and of different concentrations of the same vapor was obtained. The vapor of carbon bisulphide, for example, was found to be apparently more violently explosive than any other tested. Acetylene, which is a gas at ordinary temperatures, by comparison, explodes still more violently. Acetic acid vapors ordinarily would not be considered explosive, but at temperatures above 112° F., the flash point of the liquid, a moderately severe explosion was produced. The pressures of this explosion could be safely relieved by a vent area of one square foot to every fifty cubic feet of volume. In other words, acetic acid explosions are approximately as violent as dust explosions.

The tests described above give only a small part of all that it is desirable to know about vapor explosion hazards. Several variable factors are involved in vapor explosions; the concentration of vapor and the uniformity of the mixture, the size and shape of the structure, the type of construction as regards rigidity or flexibility of walls, the original pressure and to a certain extent the character of the source of ignition. Different

combinations of these factors may produce explosions which vary widely in strength. Tests such as these could be run almost indefinitely with no assurance that the full range of possible intensities, or even the maximum intensity, had been covered. However, the successful venting of a hundred or more tests, without one failure, shows that vents for vapor explosions are a practical safeguard and that the vent ratio of one to ten should be effective in all but the rarest cases.

Each process involving an explosion hazard must be considered by itself. However, the investigation already made has been of great value in showing that practical tests can disclose whether a hazard exists, and can provide information valuable in planning safeguards. They show that automatic venting provides a practical method for relieving destructive pressures.

Low Temperature Charring of a Wood Shelf.

This photograph shows the under side of a wooden shelf located 5 in. above a steam radiator in a railroad freight office. The board is charred clear through. No fire occurred as the condition of this piece of wood was discovered before actual ignition ensued. This wooden shelf had been in place over the radiator for a period of about 20 years. The radiator was under a window with free circulation of air in front, but as the shelf extended to the wall and there were other shelves on both sides of the radiator, the circulation of air was limited to the front. The boiler which furnished the steam had its safety valve set at 80 lbs., a higher pressure than usually used for steam heating systems. On the other hand even with this steam pressure, this effect on woodwork 5 in. away with a free air space between would seem unusual. A contributing factor in this case may have been linseed oil. A can containing some stood on the shelf for a considerable period, but had been removed at least 18 months before the charring was discovered.

A Primer on Lacquer Spraying.

By Wm. D. Milne (Member N.F.P.A.).
Underwriters' Bureau of New England.

Gun cotton and other nitro-cellulose explosives were employed in torpedoes, bombs and ammunition in the destructive work of the great war. Nitro-cellulose motion picture film has had a record of fire and tragedy which is resulting in the restriction of its non-professional use in favor of the cellulose acetate film. A nitro-cellulose not very different from gun cotton has within the past three or four years appeared in brush and spray lacquers, and the use of such lacquers has become widespread in industrial and domestic uses through the inherent merit of the product and the powerful advertising afforded to it. The dangerous properties of the basic nitro-cellulose material in these new spraying lacquers have not failed to mark the record of their use with fires and loss of life.

The spray painting hazard is not confined to pyroxylin lacquers; the spraying of ordinary paint or varnish presents serious flash fire hazards, as the fire record incorporated in this article amply demonstrates. Although the likelihood of fire in connection with the spraying of ordinary paints and varnishes is comparable to that where lacquers are used, and the precautions required are substantially the same, this article is directed principally toward the use of nitro-cellulose lacquer, as it is here that the spraying hazard is most severe and seems to have been least appreciated.

That nitro-cellulose lacquers, like gasoline and dynamite, are tremendously valuable and useful cannot be denied, but like these other materials, the dangers of which are better known and respected, they must be handled and used under conditions which will reduce the danger to life and property or substitutes for them will be required.

That general ignorance of the properties of these lacquers and of the spraying processes themselves have contributed greatly to the losses which have attended their use, is evident from a review of the fire record. In spite of warnings by experts familiar with the dangers, and in spite of the existence of carefully prepared rules for the control of the hazards attending the use of the processes, workmen, manufacturers and insurance interests have paid a heavy price in life and property. Such losses reached a climax in the automobile body factory disaster reported in detail elsewhere in this QUARTERLY.

Manufacturers laying claim to an intelligent understanding of their production processes have a special responsibility with respect to the main-

tenance of safe conditions surrounding the use of lacquers in their plants. Public authorities charged with the safety of the lives of persons in industrial and tenanted buildings have a special responsibility in the protection of the public against the ignorance or carelessness of users of the material. The manufacturers of lacquers have a special and selfish interest to protect against the effects of the use of their products under unsafe conditions. Insurance interests, both life and fire, have an obligation to themselves and the public, to promote intelligent caution in the use of the material, through the services of their inspection and publicity departments.

There is a form of hysteria which appears after disasters and which interferes with the fair and intelligent handling of the conditions surrounding the hazard. It is important that the understanding of the nature of the material and the hazards of its use be clear and widespread.

The Nature of Pyroxylin Lacquer.

Pyroxylin or nitro-cellulose lacquers, as they commonly appear today, are made by numerous manufacturers for various special uses, according to various formulae, and are sold under trade names which often give no clue as to the true nature of the material. They consist usually of a nitrocellulose, a gum or resin, an oil such as castor oil, a dye or color pigment, and a mixture of several solvents such as alcohols, acetates, toluol, xylol, etc., necessary to hold these materials in solution or suspension. They dry on application, chiefly through the evaporation of the volatile flammable solvents, and are thus similar to the so-called spirit varnishes which have long been in use.

In the liquid state, in cans or containers, they do not present a hazard appreciably greater than or different from gasoline thinned paints or varnish. This hazard is far from being negligible, but its nature is at least fairly understood by the users of such material. The exposed liquid may be easily ignited through the vapors which arise from it, by any open flame or source of heat such as electric sparks, or the minute sparks of static electrical discharges. The vapors may readily form explosive mixtures with air.

In the use of lacquers the flammable vapors of the solvents pass off into the air, as do those from varnishes and japans. They pass off at normal room temperatures and heat is not ordinarily required in the drying process, but may sometimes be used. The atmosphere of the rooms where such materials are used may be so charged with the vapors as to be explosive, while the freshly coated surfaces present an opportunity for the extremely rapid spread of fire.

The wiping rags and droppings incident to the use of pyroxylin lacquers are dangerous. They present a hazard of spontaneous heating which is as serious as the hazard of paint rags, an insidious hazard which has been a costly one in connection with paints and varnishes containing linseed or other drying oils. The nitro-cellulose of the lacquer is a relatively unstable chemical compound, and its decomposition, attended by the generation of heat, may be started by the chemical action of foreign materials in contact with it, or by very gentle warming, especially if continued. Indeed, if not properly prepared, the nitro-cellulose itself may be so unstable as to slowly decompose, though it does not appear that this possibility constitutes a hazard in the liquid material itself.

The particular process of spraying lacquer, paint, and varnish is relatively new. The material is discharged as a mist from a spray "gun" by means of compressed air. The mist and the flammable vapors which emanate from it and from freshly coated surfaces may be easily ignited from any open flame, or electric or other spark. Under certain conditions these vapors may form explosive mixtures with the air, so that upon ignition there is an explosion. If the vapor air mixture is neither too "rich" nor too "lean" and the vapor cloud is confined by walls or partitions the disruptive or explosive effect may be tremendous. Numerous spraying fires have occurred with varnishes, shellacs, paints, and pyroxylin lacquers. Such fires are dangerous because they are of the nature of flash fires or explosions, and because of the liability of their wide and rapid spread to freshly coated articles near by. There is some indication that pyroxylin lacquer spray mists are more readily ignited than are those of varnish, possibly due to the more ready formation of explosive vapor-air mixtures from the mixed solvents of the lacquers than from the single solvents of the varnish, though the relative frequency of the lacquer spray fires is largely due to the widespread use of the spray lacquers, a use for which they were especially developed.

The vapors of solvents used in paints, varnishes and lacquers are irritating, enervating, and in some cases poisonous. To remove the vapors from the work room, and to prevent the damaging of other material by the spray, hoods or booths are used to entrap and confine the spray and vapor, and air drafts are created to discharge them outside. The interior of the hoods or booths, and the vent pipes rapidly become coated with a deposit of the solid or gummy matter from the spray. By this necessary arrangement, a point of serious hazard is created.

The oily and resinous deposits from paint or varnish spraying may be ignited by spontaneous heating, by flash in the spray vapors at the booth or gun, by sparks from fan blades, heat from motors, or from any one of

many extraneous causes. When they burn, they burn persistently with great heat and much black smoke. The flues become red hot. The residues from pyroxylin differ from those from paint or varnish and in this difference lies the chief distinction in the hazard of lacquer spraying from other spraying, and the greatest danger.

Lacquer Residues or Waste Deposits.

The solid residue from lacquer is largely nitro-cellulose. The nitro-cellulose is only slightly different in chemical make-up from gun cotton, being usually a nitro-cotton nitrated to a degree between that used for pyroxylin plastic and that used for explosives. Some commercial lacquers use true gun cotton in solution, some use pyroxylin plastic in solution, and some use nitrated cotton of an intermediate degree of nitration, but as a practical matter the hazard of their residues is about the same.

Nitro-cellulose, as previously noted, is a relatively unstable compound, readily ignitable, fast burning, and susceptible to decomposition with the generation of heat and frequently ultimate self-ignition, when subject to chemical influences from foreign or waste material or to external heat. When it decomposes it evolves very large volumes of nitrous and other gases which are in themselves flammable or explosive when in proper mixture with air. When it burns, there is in advance of the point of burning a large evolution of gas. This characteristic property is the one made use of in the propellant charges of smokeless powder in rifles, and is the property which leads to the pressure rupture of film or pyroxylin plastic vaults when they are not sufficiently vented.

Small particles of nitro-cellulose dust in the atmosphere, when heated to a relatively low temperature, decompose into flammable gases occupying several times the volume, a condition which may lead to an explosive condition in the atmosphere irrespective of the dust hazard.

In lacquer spray booths and their flues the residue, which collects with great rapidity, is characteristically a friable or powdery solid, built up as a dust or as a sort of honeycomb deposit. With large objects being sprayed, the waste lacquer frequently escapes from the booth and lodges as a dust on floors, in cracks, on ledges, pipes and elsewhere.

When the deposit of dust burns, if it is relatively thin, it burns with great and accelerating rapidity, the fire flashing over the coated surface at great speed, and the fire in the nitro-cellulose is soon out, though fire in other material or on freshly coated surfaces may remain. Under such conditions the nitro-cellulose may be all gone before the heat operates sprinklers. If, on the other hand, the deposit is slightly thicker, rapid decomposition by heat proceeds in advance of the flame and a blast of

white gases is projected from the burning area. These gases ignite and burn as a sort of blow torch or sometimes form a cloud with the air, and when ignited from the parent fire explode with a violence varied by the chance proportions of the mixture.

It should be noted that fires will not spread to any great extent on the finished lacquered surface, for the coating is so thin that the metal or wood of the article exerts a cooling effect. An article finished with lacquer is no more susceptible to fire than the same article finished with paint or varnish. This presents a condition totally different from the burning characteristics of the residue, as previously described.

The recent fire and explosion in Detroit illustrates the destruction possible when the lacquer dust and deposit is spread over wide areas. The jar and the heat of the flash in a small cloud of nitrous gases from a tiny fire in lacquer deposit shook down and almost simultaneously decomposed other nitro-cellulose dust deposits and caused a rapid and brief progression of explosions, which ruptured the sprinkler system and left the building at the mercy of a fire in its ordinary contents, widespread by the first blasts of flame.

In this phenomenon of gas evolution lies one reason for insistence on daily cleaning of all spraying areas. If the deposit is slight the fire may spread rapidly and go out, leaving perhaps some fire in other material to be extinguished by sprinklers fairly readily if the area is not so great as to overtax the water supply, or the congestion or obstruction is not such as to interfere with sprinkler control. If the deposit is sufficient to result in great gas formation when fire occurs, explosion may cripple the sprinklers, lives may be lost, or the ensuing and remaining fire be too severe for control by the ordinary means.

A review of the fire record, if not a consideration of the characteristics of spray booth fires, gives convincing evidence *that a fire in a spray booth in an unsprinklered building is likely to prove disastrous,* unless the construction be fire resistive and the spraying area small and effectively isolated from others. The spray booth fires are so rapid in their development, and so smoky that operatives are driven away if not burned, while the projection of flame from the booth frequently so spreads fire that before the outside facilities are available the fire is too widespread to be handled effectively.

The Regulations.

There has been in existence for some years a set of rules prepared by the N.F.P.A. and promulgated by the National Board of Fire Underwriters, covering the hazards of spraying. The rules were prepared after a very careful study of the materials and the modes of their use. There has yet to be found the case of any spraying process fire of any importance

in which there was not a violation of these special rules or a violation of the elementary principles of fire protection, which led to the event or to its serious consequences. In fact, almost every case reviewed, whether large or small, revealed violations of these rules. While changes in manufacturing systems and materials may lead to elaboration of the rules, the principles of the existing rules will still apply.

The following principles of fire protection may be regarded as elementary, and as forcefully applying to plants where spraying is done. The so-called "spray booth rules" are merely the specialized application of these principles:—

(1) If an operation is dangerous it should be so isolated or cut-off by partitions, walls or open spaces that fire arising from it will not be communicated to other areas and that water used in its extinguishment will not do damage in adjacent or lower areas.

(2) If an area presents a hazard of rapid development of widespread fire due to the character of the material present, so that the fire extinguishing facilities will be overtaxed, that area should be so subdivided that the available extinguishing facilities will be effective.

(3) If the rate of burning of the materials involved is greater than that for which ordinary fire appliances are designed or the generation of heat is more rapid than can be overcome by the application of water or other extinguishing agent in usual amounts, the speed of action and the quantity of the extinguishing medium applied should be adequately increased.

(4) If a material is so sensitive to ignition that exposure to minor sources of heat will ignite it, all sources of heat which will cause ignition must be eliminated from the area in which the material is present.

(5) If a material is dangerous with respect to spontaneous heating special care must be given to cleanliness. General cleanliness is a fundamental precaution.

(6) If an area is dangerous, all material not immediately in use or essential to the occupancy of that area should be removed from it.

The Fire Record.

A perusal of the reports of spraying process fires in the files of the Department of Fire Record of the National Fire Protection Association reveals that these may be divided fairly readily into three classes. One group of fires resulted from processes in which varnish, shellac or paint rather than pyroxylin lacquer was sprayed. Another group of fires occurred in plants devoted to the finishing of automobile bodies with pyroxylin lacquers on a quantity basis, using conveyor systems and tunnel booths. Another group of fires occurred in plants where small booths were employed for applying pyroxylin finishes in connection with furniture or metal goods manufacture, with from one to ten booths in a single area. This group may be divided into two, according to whether the articles being made were of metal or of wood.

In all, the review covered 29 fires in spraying processes not involving pyroxylin lacquer, 84 fires in lacquer spraying operations other than auto-body tunnel operations, and 13 in auto-body conveyor tunnel operations. With a few exceptions these fires were in sprinklered plants, the reports on fires in unsprinklered plants being fragmentary for the most part. Reports on unsprinklered plant fires do not come as surely to the N.F.P.A. as do those on sprinklered plants more regularly under competent insurance inspection.

Causes of Fires.

The causes assigned in the reports on spraying process fires are apparently very frequently more or less hypothetical ones. The true causes are frequently obscured but the conditions found indicate the underlying hazard and the most probable causes.

Causes of Paint and Varnish Spraying Fires.

In the twenty-nine fires not involving pyroxylin lacquer, but involving paint, varnish or shellac, the causes appear as follows:—

In vent pipe, spontaneous or unknown	8
Fan motor, sparks or overheating	8
Electrical: Open switches 1, defective electric heater 2, broken lamp bulbs 2, short circuit at lamp plug while cleaning with gasoline 1	6
At booth, spontaneous in rags or dirt	3
Unknown at booth	2
Welding with torch (open flame)	1
Static spark	1
Total	29

Causes of Lacquer Fires in Automobile Finishing.

In the thirteen fires involving quantity finishing of automobile bodies using the conveyor tunnel system the assigned causes were as follows:—

In booth, broken lamp	4
In booth, exact cause unknown	3
In booth, pouring hot tar	1
In vent stack, exact cause unknown	2
On ceiling, over booths, etc., exact cause unknown	2
Rags on radiator	1
Total	13

It is noteworthy that in seven out of these thirteen fires no further cause was assigned other than that fire started in the waste deposits, sometimes in the presence of workmen, and frequently when spraying was not in progress. This indicates the liability of this material either to spontaneous ignition or to ignition from obscure and very minor sources of heat such as static discharges or frictional sparks. It serves to show

that even with all possible care taken, fires may still originate in this waste material in these processes. Inasmuch as the usual practice in the plants in which these fires occurred is to ventilate by induced draft, with no fans or motors in the vent pipes, the occurrence of fires in the vent stack is of interest.

Causes of Lacquer Fires in Metal and Wood Working Industries.

In the fires in connection with pyroxylin spraying in miscellaneous industries both wood and metal working, the tabulation as to causes is as follows:—

In rags and waste, spontaneous	12
Exhaust motors	11
Short circuits and open switches	10
In vent pipe, spontaneous ignition or exact cause unknown	8
Broken lamp bulbs	7
Static sparks	5
Scraping booths and dismantling	5
Smoking or matches	4
Acetylene torch	1
Soldering	1
Fan blades	1
Cause unknown or not given	19
Total	84

Again the large number of fires of unknown or unassigned causes, together with the doubt as to cause expressed in many reports and the fact that a number of the fires started when no one was present, indicates the danger of spontaneous ignition.

Summary of Causes, all Classes.

In or on booth, spontaneous ignition or exact cause unknown	27
Motors or fans in vent pipes	20
In vent pipes, spontaneous ignition or exact cause unknown	18
Rags and waste	16
Electric sparks, short circuits, etc.	14
Broken lamp bulbs	13
Static sparks	6
Scraping or dismantling booth	5
Open flames (torches, soldering irons, matches, etc.)	4
Smoking	3
Total	126

Many of these fires would have been prevented and most of the remainder would have been reduced in intensity by the strict attention to cleanliness, with daily cleaning as prescribed by the rules.

The forty-seven fires from electrical causes would have been avoided by compliance with rules excluding motors from vent ducts, requiring

standard vapor-proof electrical equipment, and requiring lamps to be fixed, double enclosed, and protected against injury. The seven fires from smoking, matches, and open flames are obviously from violation of common rules for safety.

Sprinkler Efficiency.

The number of reported fires reviewed is insufficient to afford a satisfactory statistical basis on which to judge as to the efficiency of various types of sprinkler equipment under different types of construction, especially as in a number of cases insufficient data was given.

Upon consideration of the nature of the hazard it is readily apparent that the number of sprinklers put into early operation by a fire in a spray booth or spraying area is dependent very largely upon the amount or area of pyroxylin waste deposit or freshly coated surfaces exposed to the first rapid sweep of the fire through this material. It is obvious that the heat generated by the burning out of a 4 ft. x 4 ft. booth lightly coated, will be far less than that from a 6 ft. x 10 ft. booth heavily coated, and that the sprinkler operation resulting will be less extensive. Similarly if there is but one booth the danger of widespread fire is far less than if there are six booths in proximity to each other permitting the flash of fire from one to another. The conditions as to occupancy, size and arrangements of booths, construction, and design of sprinkler systems involved in the fires under review were found to be so varied that only very general conclusions may be drawn.

In making up the following figures as to the average number of sprinklers operated per fire, those fires where failure of sprinkler protection occurred or where fire extended widely beyond the special hazard area have been excluded as far as possible, in order that the figures may be a relative measure of the intensity of the fire in the special hazard condition itself.

That the extent of the pyroxylin spraying area has a vital bearing on the extent of the fire and the consequent operation of sprinklers is well shown by the fact that in thirteen fires in the conveyor type spraying tunnels of automobile body manufacturing plants, 819 sprinklers operated, an average of 63 sprinklers per fire. These figures do not include the recent Detroit disaster nor any fire in which the general occupancy or structure was involved. In fact, in eleven of these cases the construction was fire-resistive.

Compared with this is the average figure of 5.2 sprinklers opening per fire in forty-two fires in pyroxylin spraying operations on metal goods, such as lamps, electrical fixtures, machine parts, etc., an average of 18.5 sprinklers opening per fire in fifteen fires in woodworkers, chiefly furniture

factories, and an average of 5.5 sprinklers opened per fire in nine fires in miscellaneous automobile plant spray booths other than tunnel or conveyor type booths.

The comparison of figures in the preceding paragraph in regard to the extent of sprinkler operation in metal working and woodworking occupancies is especially interesting. The figure of 18.5 sprinklers opened per fire in woodworking occupancies as against 5.2 sprinklers per fire in metal working occupancies seems to indicate the effect of the generally greater combustibility of the contents, and the larger booths employed in the woodworking plants. It happens also that three serious fires, opening a total of 606 sprinklers, which were not included in making up these averages, also took place in woodworking plants.

A compilation of the figures for sprinklers operated, under fire-resistive construction, timber construction, and joisted construction, does not appear to indicate any particular advantage with respect to sprinkler control under timber construction over sprinkler control under joist construction, for this hazard, but does seem to indicate an advantage for fire-resistive construction. The comparison is believed to be of little value in view of the variety of other conditions affecting the matter.

Various compilations tend to show that the water pressure available for sprinklers has a marked bearing on the promptness of sprinkler control for this hazard, though again the statistical basis for such comparisons is unsatisfactory. In thirty-two fires with sprinklers under a pressure in excess of 50 lbs., 7.3 sprinklers opened per fire, while in twenty-two fires with water pressure below 50 lbs., 23 sprinklers opened per fire, (excluding disasters, and excluding automobile body plant fires). In a group of ten fires under sprinkler protection at water pressures below 30 lbs., an average of 28.9 sprinklers opened per fire.

The records seem to show that with the exception of very large booths as used in the automobile industry, sprinklers have very seldom been provided in the booths themselves, as called for in the rules. The data in numerous reports was indefinite in regard to the matter, and it seems impossible to draw from the reports any evidence as to the effectiveness of sprinklers in the booths themselves. It seems evident, however, that the provision of a sprinkler or sprinklers in the booth, and perhaps in the vent ducts, is of material benefit, especially if the sprinklers are more sensitive than the ordinary solder release type.

The records fail to give sufficient basis for any comparison of the efficiency of sprinklers on various schedules of pipe sizes, over the spraying process hazard.

There were several instances in which the fire was spread, sometimes to other floors, because the vent pipe was insufficiently insulated or clear of woodwork or combustible material, also instances of water damage to floors below following spray booth fires.

Of four large loss fires due to the lacquer spraying hazard, all of which were in woodworking occupancies, one was due in part to an interruption of the sprinkler protection at a critical time, and in part due to the spread of fire through a duct system which connected not only several spray booths in violation of the rules but also other woodworking rooms. Five hundred and seventy-eight sprinklers opened in this fire. Another occurred in a heavily congested room where six spray booths were located, connected to a common exhaust. The fire started while the fan was shut down, probably from smoking, and spread rapidly in heavy deposits of lacquer, opening 192 sprinklers. In this case the water supply was weak and the initial pressure only 33 lbs. The third occurred in a frame joisted building sprinklered on a dry system with a water pressure of only 22 lbs.; 54 sprinklers opened. The fourth occurred in a frame joisted furniture factory sprinklered with a sub-standard dry-pipe system carrying 75 lbs. air pressure. Sprinklers were badly obstructed by joists and decks; 236 opened. In these last two cases the protection provided was obviously too weak for the special hazard if not for the protection of the general occupancy.

Varnish Spraying.

Of the spraying hazard fires in which other than pyroxylin lacquer was involved, seven fires, all in furniture factories, show very heavy losses. A summary of each of these fires is given following this article. There is a flash fire hazard connected with varnish spraying which, as with lacquer spraying, is very serious, especially if the area surrounding the spraying operation contains large quantities of light combustible materials. If fire develops in the vapor or in the resinous deposits it will spread rapidly and find much to burn. Prompt and powerful action by the sprinkler system is needed to control the fire. A perusal of the descriptions of these fires is illuminating as to the conditions of occupancy and care which existed in these plants, but special note should be taken of the fact that sprinklers were on dry systems in six of the seven cases, the construction was joisted in six cases, initial water pressure was below 40 lbs. in most cases, and there were sprinkler system deficiencies in some cases. With the general conditions of occupancy present in such plants, it seems reasonable to assume that with the retarded action of dry system sprinklers and the relatively weak delivery of water due to low pressure, the protection provided was insufficient for effective sprinkler control of fire.

Typical Fires.

Summaries furnished by the N.F.P.A. Department of Fire Record.

Lacquer Spraying Fires in Automobile Body Plants.

S-43158. DETROIT, MICH., JUNE 11, 1926. CLOSED TYPE AUTOMOBILE BODIES. Fire started from an unknown cause in an all-metal construction spray tunnel where pyroxylin enamel finishes are applied to closed type automobile bodies. This fire is a repetition of similar fires that have occurred in this location. The bodies are started on a conveyor chain and run through two sets of triple tunnels separated by a low temperature drying room. Tunnels are 62 ft. long with open sides and ends, three in a bank in each set, each set covering a floor area of 38 ft. in width and 60 ft. in length. It has always been the practice at this plant to clean out spraying tunnels each night after the workmen leave, but cleaning was not done this night as the men were laid off for a few days and tunnels were left to be cleaned the following day. Cleaning under the gratings had been neglected for some time and this accumulation together with one day's deposit in tunnels accounted for the intensity of the fire, which resulted in a large volume of dense smoke and gases. Forty-eight sprinklers on a wet system in tunnels were said to have operated at once which confined the fire in the booths. Heat waves opened ninety-three additional sprinklers in one end of the spraying room. This room is cut off by 8 in. tile and cinder block curtain walls with openings protected by single fire doors. These doors were closed by hand and no sprinklers opened in the adjoining section. The pressure on the first sprinklers operating was 42 lbs. The public fire department played six hose streams on the fire. The loss was estimated at $125,000.

S-43160. DETROIT, MICH., JUNE 13, 1926. CLOSED AUTOMOBILE BODIES. This was the second fire within two days in the same spraying department. This fire occurred in the opposite set of pyroxylin enamel spray tunnels from the one the preceding day. Some cleaning up had been done after the preceding fire, but the conveyor chains that run through each tunnel had been neglected. While the workmen were pouring hot mastic composition flooring on the floor of the spray tunnel some was accidentally spilled on the conveyor chain. The pyroxylin lacquer residue on the chain immediately caught fire. The first flash was on a chain in the tunnel at one side; it spread to chains in adjoining tunnels, and to metal canopies. Sprinklers on a wet system opened in spray tunnels and motor room on roof; heat waves opened sprinklers in spraying department which made a total of 106 sprinklers operating in addition to those manually controlled in stacks. The pressure was estimated at 35 lbs. on the sprinklers first operating. The fire department used two hose streams and employees used two streams to completely extinguish the fire. The loss was small.

S-42972. HAMTRAMCK, MICH., APRIL 15, 1926. AUTOMOBILES. Fire started in the new body building in the lacquer spraying department. It originated in some waste rags that had been thrown between steam radiators and wall of room. Fire then extended to lacquer dust on ra-

diators and window sills and jumped into spray booths before the employees could extinguish it. By the time the plant fire department arrived the fire had spread into the vent stacks and to the tops of the booths. The several open pails of thinner added fuel to the flames. One hundred and thirty-eight sprinklers in booths, stacks and in the rooms operated and several chemical extinguishers were used. Sprinklers that operated were on a wet system and the pressure was 21 lbs. The loss was about $1,300.

S-42977. HAMTRAMCK, MICH., MAY 8, 1926. AUTOMOBILES. Fire started in the same location as the fire of April 15 (S-42972), except this time it was in the spray booths on the opposite side of the room. Employees were cleaning up after the day's work and the fans were still running to completely exhaust the lacquer fumes from the room. Fire started on top of the spray booths from an unknown cause and immediately followed the pyroxylin dust on vent pipes and then extended into the booths on the floors. Eighty-two sprinklers operated inside of the booths and stacks and in the room. Chemical extinguishers were used to complete the extinguishment of the fire. The quick operation of the sprinklers again stopped the spread of the fire. Sprinklers were on a wet system with 21 lbs. pressure. Loss was $300.

S-39721. ST. LOUIS, MO., MAY 13, 1925. AUTOMOBILE ASSEMBLING. A flash fire, from unknown cause, occurred while an employee was cleaning up the pyroxylin enamel room. Nine sprinklers (wet system, pressure 90 lbs.) operated and practically extinguished the fire. One man was burned to death and two men were slightly burned. The loss was $200.

S-41886. GRAND RAPIDS, MICH., FEBRUARY 11, 1926. AUTOMOBILE BODIES. A fire in a spray tunnel used for applying a pyroxylin finish caused the death of one employee and the serious injury of another, but was extinguished with small damage, thus furnishing an interesting example of the efficacy of the various measures recommended by the N.F.P.A. The start of the fire and the death of the employee were, however, due to the use of an unprotected electric light bulb contrary to these recommendations. One hundred and twenty-six sprinklers operated and extinguished the fire with a loss of only $1,800. The fire came at the peak of a heavy production program. It occurred at 8:40 P. M.; manufacturing operations proceeded as usual the following morning. (For complete details see QUARTERLY, Vol. 19, No. 4, page 388.)

Lacquer Spraying Fires in Other Than Automobile Body Plants.

S-44771. LOS ANGELES, CALIF., APRIL 23, 1927. FURNITURE FACTORY. This fire occurred when an employee was engaged in spraying an article of furniture. This employee reported that he observed a spark near the fan motor and reached to shut down the motor. However, before he could stop there was a flash followed by fire. The employee fortunately was not burned. The exact cause of the spark is not clearly known, but investigation revealed that at some previous time a hole about 2 in. long had been opened in the hollow fan arm probably to repair the feed wires. This hole had never been closed and it is believed that the wiring inside was the source of the spark. Otherwise the wiring in the booth was all

concealed and there were vapor-proof globes on the light bulbs in front of the booth. The material used in spraying was a lacquer of nitro-cellulose base and the booth walls and vent duct were heavily coated with the residue. Nineteen sprinklers on a wet system with a pressure of 28 lbs. operated and held the fire in check. First aid equipment near the booth could not be used on account of the fire. Six hose streams were used by the public fire department to completely extinguish the fire. The loss was $4,617.83.

S-39562. KITCHENER, ONT., APRIL 8, 1925. FURNITURE FACTORY. Two booths using pyroxylin lacquer for finishing furniture were located at opposite ends of the top floor of a three-story building. The booths were about ninety feet apart and close to the side walls of the building. They faced away from each other and toward the end walls, which were ten to fifteen feet distant in each case. Both spray booths were of metal about ten feet square and each was ventilated by a large exhaust pipe extending up through the roof. At about 10 A. M. one of the booths, which had been idle since the previous day, was discovered to be on fire, apparently due to spontaneous ignition in the accumulation of lacquer on the walls and floor of the booth. There were no sprinklers in the booths and an employee tried to use a pail of sand on the fire, but the heat and fumes drove him from the room. The flames from the ventilator set fire to the tar roof-covering which had been recently laid and had not been covered with gravel. A strong wind quickly spread the fire over the roof to the other ventilator, igniting the deposit of lacquer inside the pipe. The fire then flashed down into the second booth. Eleven sprinklers opened around the first booth and twelve around the second. Sprinklers were on a wet system and the pressure was 35 lbs. Sprinklers protected the building and contents so well that only a small area of the roof was charred in front of each booth. Although the fire damage was less than $1,000 the water damage was $25,000.

S-39546. GRAND RAPIDS, MICH., FEBRUARY 6, 1925. FURNITURE FACTORY. Fire started on the top floor of the center section in the spraying and finishing department, originating in a box of sweepings and waste materials from pyroxylin lacquer spraying operations. Three sprinkler heads (dry-pipe system) opened directly over the box and extinguished the fire. The water was then shut off to replace these heads.

Over this box was a duct leading from a spray booth. This was operated on an induced draft system. The secondary air supply instead of being drawn from outside the building was taken from the woodworking machine floor, one large fan supplying a number of spray booths. This resulted in a deposit of wood dust throughout the system. Shortly after the fire was extinguished a fireman noted that part of this air blast pipe was red hot, indicating an internal fire. From two to four minutes elapsed before the water was again turned on the sprinkler system and during this interval the fire flashed to the spray booths and throughout the upper portion of the building opening 378 heads. The loss was heavy, largely water damage. (For further details see QUARTERLY, Vol. 18, No. 4, page 388.)

S-39459. PHILADELPHIA, PA., FEBRUARY 24, 1925. RADIO CABINETS. A finishing coat of pyroxylin lacquer was applied in spray booths on the third story of the main building. A deposit of pyroxylin lacquer had accumulated to a thickness of one-fourth inch on the walls and one inch on the floor of the booths. During the noon hour while the spraying process was stopped due to trouble with the exhaust fan white vapors were noted rising from the floor inside one of the booths. Sand was immediately applied and the fire apparently extinguished, but a few minutes later the whole interior of the booth burst into flame. There were no sprinklers in the booth and in the few seconds before the sprinklers in the main room operated the fire spread to adjoining spray booths. One hundred and ninety-two sprinklers opened and prevented the further spread of fire after the initial flash. The 25,000 gallon gravity tank was exhausted before the fire department arrived and the city water pressure was lowered by the large demand made upon it by sprinklers and hose streams. (For further details see QUARTERLY, Vol. 18, No. 4, page 385.)

S-41993. OSHKOSH, WIS., APRIL 10, 1926. FURNITURE FACTORY. An employee at a lacquer spray booth had superficially cleaned the booth and instead of taking the refuse directly to the boiler room, as strictly instructed, had deposited it on a wooden truck, which contained sweepings of moss, tow and excelsior, located near the partition between the spraying and upholstery rooms. Fire started from spontaneous ignition of the paint refuse. The fire rose immediately along the wall and spread rapidly in the space between the roof and the ceiling of the upholstery room. When the sprinklers operated, the escaping air pressure, much in excess of requirements (75 lbs. instead of 30 lbs.) not only served to intensify the fire in this space, but forced the flames to spread. It was apparent that the fire traveled faster than the sprinklers opened, except at one end of the building, where the heat banked and opened the sprinklers before the arrival of the flames. Two hundred and thirty-six sprinklers opened during the fire. The public fire department also used five hose streams. The sprinklers were reported as operating effectively everywhere except under an unsprinklered deck, where no water was reaching. A steamer connection was not used because the fire chief did not know that this connection served the sprinklers in any building other than that in front of which it was located; this in spite of the fact that the fire department makes quarterly inspections of this plant. Damage to the building was small but the estimated loss was $70,000, almost entirely a water damage. Twelve of the firemen were overcome by smoke which was so dense that the fire could not be located and hose streams were being played on the third floor, where there was no fire, for some time.

S-42460. CHICAGO, ILL., JUNE 15, 1926. PICTURE FRAMES. Whiting and finishing picture frames was done at this plant. The fire was caused by the ignition of pyroxylin lacquer and paint deposits. Certain pyroxylin representatives were demonstrating their product by coating some samples and when finished, ordered one of the employees to clean the booths they were using. This he proceeded to do in the manner customary at the plant, that is by scraping off the deposits. The friction of scraping ignited

the deposits with a flash and singed the employee before he could get away. Forty sprinklers operated (single supply, gravity tank) and held the fire in check. While the sprinklers were an important factor in preventing the spread of the fire they operated too slowly for such quick burning substances as pyroxylin. The building loss was slight, the contents loss from fire small, but the water damage was considerable.

Varnish Spraying Fires in Furniture Factories.

S-44489. PULASKI, N. Y., DECEMBER 30, 1926. FURNITURE FACTORY. Varnish was used for spraying at an unsprinklered metal spray booth. An employee turning on an open electric switch with the spray gun in his hand had the varnish on his hands ignited by a spark. He immediately gave the alarm and dropped the gun on the floor, the varnish at the same time igniting. Fire quickly spread to the floor and ceiling and varnish container nearby. Flowing varnish augmented the blaze. Fifty-four sprinklers on a dry system with a static pressure of 35 lbs. operated and practically extinguished the fire. Fire and water damage amounting to $9,208.49 was done to stock of furniture and to ceilings and walls.

S-31350. MT. AIRY, N. C., OCTOBER 26, 1921. FURNITURE FACTORY. The fire occurred in a spray booth used for enamel spraying, due to a spark from a fan blade igniting benzine fumes. At the time of the fire the plant was running at night until 8 P. M. The operator of the spraying machine had noticed toward the close of the day that a blade of the fan in the vent from the spray cabinet was loose. At about 7:45 P. M., operations in the spraying department were stopped as usual, and the operator washed out the hose from the enamel container to the spraying nozzle with benzine in order to keep the hose clear of dried enamel. He then called the foreman to show him the defective fan. As the motor was started a flash fire spread through the cabinet and flames burst out into the room. Thirty-two sprinklers on a dry system with 60 to 75 pounds static pressure on top line of sprinklers operated and a line of hose from private hydrant was soon playing on the fire. The public fire department used two hose streams until the fire seemed to be out and the water was turned off the sprinklers. Fire broke out again, however, in an accumulation of paint, varnish and enamel in and around the spraying cabinet and water had to be again turned on the sprinklers. The loss was $30,266, of which less than $100 was fire damage and the balance water damage.

S-45123. BASSETT, VA., FEBRUARY 23, 1925. FURNITURE FACTORY. Fire started at a spraying machine in the finishing room. It was caused by sparks in or near a motor which apparently short circuited when an attempt was made to start it when the fan blades were stuck by a gummy deposit. The spraying machine had been running all day under humid atmospheric conditions outside and heat had been maintained in the building causing the room to be saturated with flammable vapors. On account of the fact that only one motor fan was operating during the entire day, the vapors had accumulated in the machine and throughout the whole

finishing room in much larger quantities than usual. These vapors being heavier than air, settled at floor level, and no doubt supported rapid spread of fire on newly finished furniture. The superintendent attempted to bring a hose stream into the room, but was unable to on account of the dense smoke. Only the sprinkler system was used, every head on the dry system opening, and this confined the fire to the third floor for three hours. The roof then fell, breaking into the second floor and wrecking the sprinkler system. By this time the water supplies were exhausted and the fire rapidly consumed the remaining portions of the building. The building was a total loss with an insurance loss of approximately $300,000.

S-45126. MARIETTA, GA., APRIL 20, 1926. FURNITURE FACTORY. Fire originated in the finishing room, which is located on the second floor of the finishing building and warehouse. By the good work of the employees in attempting to extinguish the fire, also the early arrival of the public fire department, together with the assistance of the 430 sprinklers which operated, the fire was confined to this building alone. There were three spraying booths on the floor in which the fire originated. The care and cleanliness in the room was very good as the owners were well aware of the hazards involved in the spraying process. The fire originated in the center booth, in the fan motor which was located in the main duct, which forced the fumes to the outside of the building. The report states that the air blast from the dry-pipe system aided the fire in spreading throughout the room and caused the operation of all the 81 sprinklers in this room. The operatives jumped from the windows when the fire first originated and left the fan motors in spraying booths in operation; these fans being in operation tended to force the fire around the booths to the outside of the building, and the flames leaping upward were sucked in at the open windows on the floor above. When the sprinklers on this floor began operating, the system was not able to hold the fire and the building was practically destroyed. The pipe sizes in the dry-pipe sprinkler system was substandard, the static pressures of the primary supply was 45 lbs. The loss was approximately $90,000.

S-45127. ATLANTA, GA., JUNE 13, 1926. FURNITURE FACTORY. Fire originated at the exhaust fan of a spray booth. An employee had filled a bucket of shellac, hoisted it into position and turned compressed air on the guns preparatory to spraying. When he switched on the fan, fire started around the motor and almost immediately spread throughout the booth. The exact cause of the fire is not ascertainable, but it was undoubtedly due to motor being gummed up and arcing or a short circuit of wiring at the motor. One sprinkler on a wet system with a static pressure of 30 lbs. operated in the spray booth and 45 sprinklers near the booth opened and practically extinguished the fire. Firemen stated that a small explosion occurred shortly after they entered this floor, due undoubtedly to the dropping of the bucket of shellac and the spreading of the shellac over a fairly wide area, when the rope supporting the bucket burned through. Firemen used one stream to extinguish the fire. The loss was estimated at $13,965.

S-45130. LENOIR, N. C., NOVEMBER 30, 1926. FURNITURE FACTORY. There were two spray booths located on the second floor of the finishing building and also one spray gun that was not enclosed in a booth. Both booths were connected with exhaust fans and another exhaust fan was located near the spray gun that was not in a booth. The wiring in proximity to one booth was in rigid conduit with electric light bulbs protected by vapor-proof globes. The wiring at the other booth was not in conduit and the electric light bulbs were without protection. The fire originated at the spray booth in which the ordinary, unprotected light bulbs were installed. It was caused from improper handling of the spray gun while being cleaned in close proximity to unprotected incandescent lamps. Nine employees were at work on the third floor, one of whom was burned to death, the remainder were injured by jumping from the third story windows. The employee who was burned to death was suffocated while trying to gain the outside by going down the stairs via the second floor. About 600 sprinklers operated on a dry system with a water supply giving a static pressure of 75 lbs. on the top line of sprinklers, but deficient in volume. The loss was about $260,000.

S-45138. THOMASVILLE, N. C., APRIL 3, 1925. FURNITURE FACTORY. Fire originated in a motor within the spray booth, while the motor was being repaired. The spray booth had been in operation for about two hours, when some trouble developed in the motor which was in the booth and directly connected to the exhaust fan. Three employees grabbed chemical extinguishers, but the heat was so intense all had to run from the building. One hundred and seventy-one sprinklers on a dry-pipe system with a pressure of 36 lbs. operated and hose streams were used to complete the extinguishment of the fire. The loss was about $50,000.

Briggs Body Plant Fire.

By E. Schuenemann and H. B. Fox (Members N.F.P.A.).
Western Factory Insurance Association.

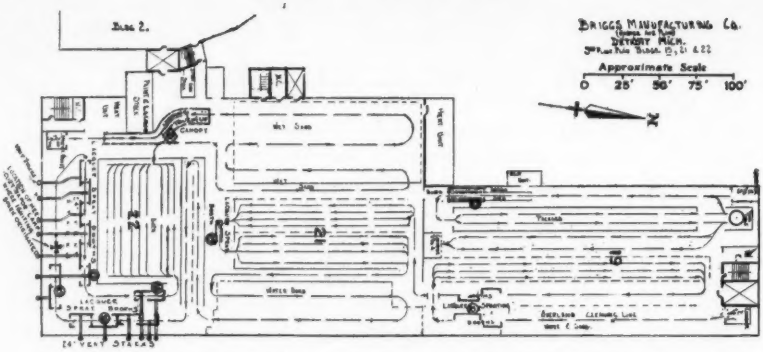
A lack of appreciation of the needed elementary precautions against the start and spread of fire, inspired by a desire for rapid production, was responsible for the death of twenty-three persons in the fire and incidental explosions which destroyed about one-half of the Harper Avenue Plant of the Briggs Manufacturing Company in Detroit on April 23. The property loss may exceed $2,000,000 and the production of automobile bodies which had been speeded up to supply peak demands has been interrupted for some time.

The accompanying diagrams show the general layout of the plant and the diagram of the third floor of the destroyed portion of the plant shows how the spraying departments in which the fire originated were arranged. Automobile bodies were forced through the spraying and drying operations on conveyor equipment which could speed up the movement of the bodies to meet production demands. The use of this type of intra-factory transportation necessitated the frequent piercing of former fire walls and floors which resulted in the impairment of these fire cutoffs to the point of uselessness. An open body hoist pierced the fourth floor directly over the spraying department.

The factory building itself was semi-mill construction and sprinklered. The partitions of the drying rooms adjacent to the spraying department on the third floor were of fire-resistive wall board on wood studs, and the ceiling of the spraying rooms was sheathed with this wall board.

There were seven double or twin tunnel type metal spray booths arranged as shown on the accompanying diagram, each booth about 30 ft. long by 8 ft. wide and 7 ft. high. The booths were arranged in groups, being open at each end to admit the bodies on the conveyors so that a fire in one would spread readily to the others in the group. Each booth was ventilated by a separate metal exhaust duct operated by induced draft by fans (drawing from outdoors), the motors being located in the room near the outside wall discharging to outdoor stacks. No special provision was, however, made to supply fresh air to the spray room itself, and at the time of the fire all windows were closed.

There was also an unsprinklered open side spray canopy for touch up work near this group of booths. The other spray booths and their exhaust pipes were protected with a complete wet sprinkler system.



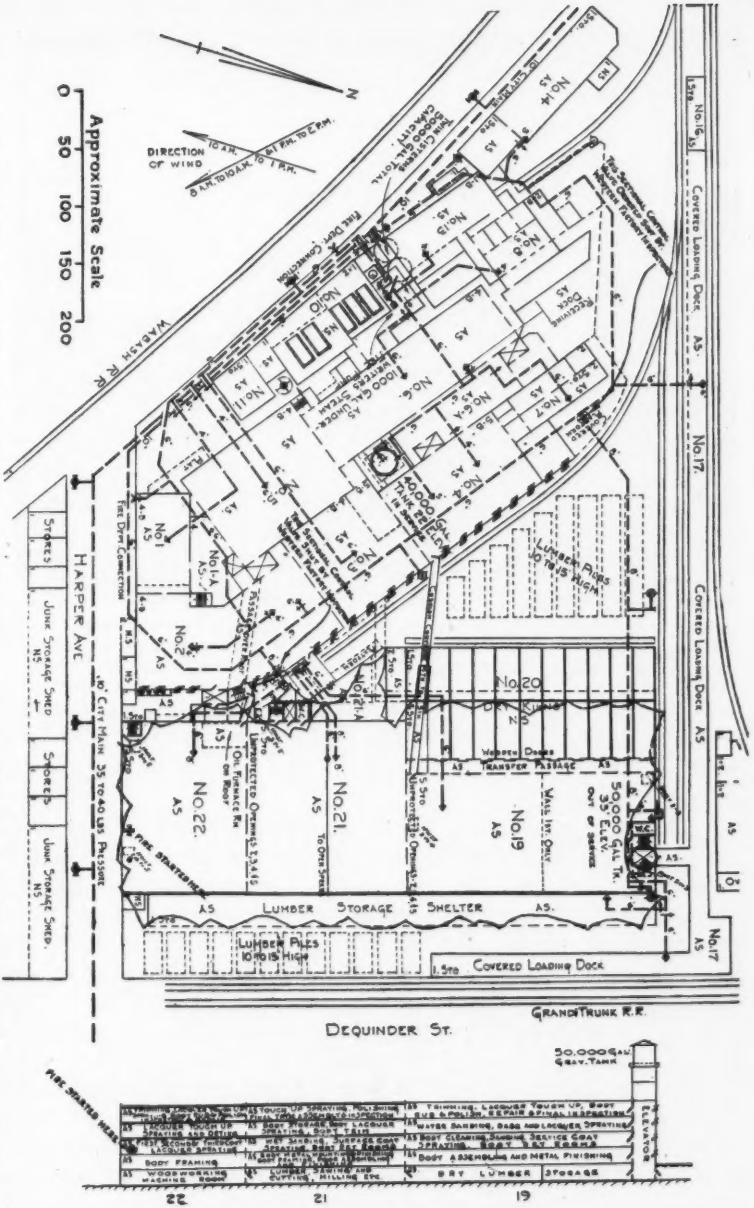
A diagram of the third floor of the sections in which the fire started and first spread through. Note the lines showing the continuous conveyor system, the use of which occasioned the piercing of fire walls and floors and ceilings.

In pyroxylin lacquer spraying operations that portion of the lacquer that does not evaporate or adhere to the product is drawn off through the vents of the booth or precipitates on baffles and other projections inside of booths and outside of the booths on ceiling beams, tops of booths or the surface of any other object. The wall board sheathing on the ceiling of this spray room being broken in places, the pyroxylin dust had undoubtedly penetrated these concealed spaces. Dust apparently had also settled on the mercury vapor lighting equipment. Under the pressure of forced production, the regular cleaning up of these deposits, and attention to other details of housekeeping were at times known to be neglected.

The fire started as the plant was starting operations. From the accounts of workmen present, the spark which started the fire came from the auxiliary equipment of a mercury vapor lamp. A flash of flame was also seen at one end of the vapor tube. This spark apparently ignited some of the pyroxylin dust or residue. Before the switch controlling the lights could be pulled, a mild explosion occurred at this point, followed by a second explosion of greater violence which blew out the windows, wrecked the sprinkler piping, booth equipment and vents, and probably some of the pipes which supplied lacquer to the booths from tanks on the floor above.

Apparently the first explosion was enough to shake pyroxylin dust, of which there was considerable on the ceilings and on objects in the rooms, into the air, and the second explosion was probably partly a pyroxylin dust explosion, and partly the explosion of the gases formed by the decomposition of residue from the heat of the first flash.

Of the 200 employees in the destroyed parts, some 40 or 50 were on the third floors of the sections shown on the accompanying diagrams as



General plan of the automobile body plant showing the portion destroyed by this fire. The sectional diagram shows the processes involved.

SECTION THROUGH BUILDINGS 19, 21, 22.

Underwood and Underwood.

The furious burning of the fire in its early stages. There were 200 men in the building and nearly 50 on the floor where the fire occurred. Several were killed outright in the fire, and the total fatalities were twenty-three.

Nos. 22 and 21. Several workmen were killed outright by the blasts and most of the other fatalities were cases of workmen who were so badly burned by the furiously spreading fire as not to recover although they got out of the building.

Following the explosions the fire spread rapidly through section No. 22 and into section No. 21 through the large unprotected wall openings demanded by the conveying system, following the conveyor lines and feeding on pyroxylin residues adhering to floors, ceilings, conveyor equipment and other objects. The fire was intensified by lacquer discharging from the broken lacquer supply pipes. The fire quickly extended into the fourth and fifth stories through the unprotected body hoist openings, encountering more pyroxylin residues and stock in process. With the sprinkler protection crippled, the spread of fire was rapid in all parts, involving the three upper floors at once and later extending downward to the lower floors.

Five fire alarms in rapid succession, the first at 8:15 A. M., were sent in for this fire. As the fire had made great headway before the fire department arrived, attempts to check the fire in the burning group of build-

Looking at the end of the building where the fire started after the first furious blazes had somewhat spent themselves. The fire started on the third floor and quickly spread to the floors above through unprotected openings.

ings were futile, so efforts were concentrated, with success, on saving the older or west portion of the plant. The physical divisions made it possible for the fire department to do this, although several times the fire threatened to penetrate into the wooden bridge over the roof of section No. 2, and also, by feeding on stock for upholstered seats which was hanging on a conveyor, threatened to enter the enclosed bridge connecting sections No. 4 and No. 19.

With the possibility of such a fire as this in mind, sectional control valves had been provided on the sprinkler system. As it was soon evident that water supplies were being needlessly bled into the doomed buildings, a W.F.I.A. engineer risked his life to close a sectional control valve in the basement of section No. 2 and then ordered the closing of the valve under a loading dock of section No. 7. In all 34 hose streams from 26 fire department pumpers were used and the fire was under control by 2 P. M.

Lessons of the Fire.

This loss of life and property can be charged to modern intensive production methods. Pyroxylin spraying operations are initially respon-

Underwood and Underwood.

The absence of protection of openings in firewalls allowed the fire to spread readily along the entire length of these buildings from the part of the third floor in left of this view and upward through unprotected hoistways to the fourth and fifth floors. These consumed, the fire is here shown working down to the lower floors.

sible; but production methods set the scene for the fire, in that, in the interest of production fire wall divisions had been rendered useless, floor cut-offs nullified, and hazardous operations crowded into unsuitable quarters.

Short of entirely rebuilding establishments of this kind, a fire protection engineer is handicapped in the handling of problems of this nature and can apply only partial preventives or remedies. Such was done at this plant by perfecting, where possible, remaining divisions between the old and new plant, installing sectional control valves and at one time securing complete sprinkler protection of the spraying operations as well as introducing a host of minor safeguards. The fire divisions provided did their duty and together with the presence and timely use of sectional control valves made it possible to save half of the plant. No serious defects in water supplies or capacity of underground mains were developed. Overhead sprinkler equipment probably never had an opportunity to function, as very likely the initial explosions disrupted the piping in the third floor of section No. 22 and in the ducts and spray booths therein, to

The fire ruins. The buildings at the right were the sections saved. The firedoors showing on the walls still standing, backed up by sprinklers, kept the fire out of the western sections of the factory.

such an extent that the water supplies were bled almost to exhaustion at the outset.

The unusual hazards of pyroxylin spraying operations, unless surrounded with every possible safeguard, are probably not yet fully realized. Former standards and methods, to which the industry has been accustomed to accept as safe in the use of paints, varnishes and enamels, are at times unsafe and extremely dangerous when pyroxylin materials are used, as the basic properties of the residues produced therefrom are entirely different.

The residues from pyroxylin spraying materials ignite almost instantly, and frequently flash, spreading the fire over a large area. The result of this is further decomposition of these residues and burning or smouldering which produces huge volumes of smoke and gases. This combination of flash, smoulder, smoke and explosion forms successive cycles in a fire of this kind as these phenomena follow each other, sometimes separated only by seconds. Such fires and explosions made possible in congested departments, if not severe enough to disrupt sprinkler systems, are entirely too quick to be controlled by an ordinary automatic sprinkler system. If, added to these conditions, there is found a congestion of combustible stocks, absence of wall and floor divisions, lax housekeeping, then severe losses appear likely to reoccur. The initial cause, while important, is relatively secondary.

This fire primarily demonstrates:

(1) The need of effectively segregating, between positive vertical and horizontal cut offs, all pyroxylin spraying processes of major proportions so that they may not prove a menace to large and vulnerable buildings.

(2) The need of exceptional cleanliness and good housekeeping in pyroxylin finishing departments, best made certain by a nightly wash down of all equipment.

(3) The need of perfectly balanced ventilation providing for adequate inlet facilities for fresh air as well as the discharge of residue and vapors.

(4) The need of placing spraying equipment so that discharge ducts need not be of excessive length, producing explosion chambers difficult to clean and protect.

(5) The inability of ordinary sprinklers to function quickly enough to confine pyroxylin spray booth fires to the point of origin.

(6) The absolute necessity of safeguarding all usual common hazards such as electric lighting and power devices, particularly mercury lamps with bare terminals and unguarded heat producing auxiliary attachments.

(7) The great value of sectional control valves in fire mains supplemented by the familiarity of those in charge of the equipment as to their purpose and operation.

(8) The undesirability of sheathed ceilings unless kept in perfect repair.

(9) The importance of keeping easily damaged stock out of buildings containing pyroxylin spraying operations unless such operations are fully segregated and floors under same fully waterproofed and drained.

Sprinkler Control—Pipe Sizes and Spacing.

An Analysis of the N.F.P.A. Fire Record.

By Henry A. Fiske.[1]
(Member N.F.P.A.)

During the past winter the writer made a study of reports of fires in properties equipped with automatic sprinklers, covering approximately the last ten-year period; these reports being on file at the office of the National Fire Protection Association, Boston. The object was to determine and tabulate the causes which account for large losses in such properties, having particularly in mind pipe sizes and spacing. The annual statistics of the N.F.P.A. covering fires in sprinklered properties do not take into account the amount of loss and it was felt that such an analysis would be of interest. It also seemed desirable to make a careful study of reports of serious fires to determine the factors which account for such fires so far as can be learned from the reports on file.

The difficulty of determining the chief or controlling factor, or reasons for large loss, through the study of fire reports, is recognized, and in many cases there may be several factors which have an important bearing on the loss. On the other hand, many of the reports are made after careful investigation by experts and their conclusions are of much value in a study of the results of automatic sprinkler protection as shown by actual fires.

The total number of fire reports in the period from January 1, 1916, to the latter part of 1926 is approximately 19,000. No study was made of fires which opened less than 25 sprinklers, or fires which opened more than 25 sprinklers where the N.F.P.A. classed the fire as "held in check" or "extinguished" and where the loss was less than approximately $10,000. It was felt that fires that did not open over 25 sprinklers could be omitted from any analysis of serious fires. Similarly no special study seemed necessary of sprinkler fires where the control was satisfactory and the loss relatively small, even though a considerable number of heads opened.

[1]Mr. Fiske was connected with the initiation of the fire record activities of the N.F.P.A. in 1897, devised the general classification of sprinklered fires which is used by the N.F.P.A. Department of Fire Record, and as the first editor of the QUARTERLY had charge of Association's fire records for a number of years. Since that time he has kept in close touch with this work at the Executive Office, in the study of fire reports, with particular reference to the efficiency of automatic sprinkler systems.—ED.

The detailed analysis covers 1,326 fires and is divided into two main divisions.

I. Fires held in check or extinguished.
II. Fires which were not satisfactorily controlled.

These two general divisions are divided into 19 items with further class divisions. These class divisions are of two types, one being a hazard classification and the other a classification of causes or conditions.

The fire hazards, i.e., processes or occupancy, are divided into three classes:

Class X. Mercantiles and similar or lesser fire hazards, including a few hazards which might be considered as special hazards but which are not classed as manufacturing properties, such as Garages, Theatres, Printing, Drug Risks, Wholesale Groceries, Warehouses (except as included in Class Z).

Class Y. The general class of manufacturing properties exclusive of the extra hazardous processes or properties included in Class Z.

Class Z. Extra hazardous properties, chiefly the following or similar hazards: Cereal and feed mills; chemical works; cooper shops; cork works; dry kilns (lumber); degreasing plants; excelsior factories; furniture storage; grain elevators; glass works; flammable liquids and compounds in considerable volume, including such processes as mixing, spreading, dipping, and spraying; mattress factories; oil cloth, linoleum and oil clothing; powder plants; pyroxylin products (celluloid, films, etc.); roofing works; saw mills; warehouses (fibre, wastepaper, tiered cotton, jute, furniture, rags, waste, etc.).

The factors affecting sprinkler control are classified as follows:

(a) Obstructions to distribution, stock, platforms, etc.
(b) Floor openings unprotected
(c) Sheathing and concealed spaces
(d) Unsprinklered enclosures
(e) Poor or light water supply
(f) Joist construction, 1-3-6 piping, not staggered
(g) Joist construction, modern standard
(h) Slow action of dry system
(j) Piping or sprinklers clogged with sediment
(k) Frozen piping (not closed valves)
(l) Fire on outside, underneath, or on roofs
(m) Hazard of occupancy, control expected
(n) Hazard of occupancy, quick spread, control not certain
(o) Miscellaneous.

NOTE:—The 1-3-6 schedule of pipe sizes was in general use up to about 1905. This schedule provides for 1 sprinkler on ¾-inch pipe, 3 sprinklers on 1-inch pipe, 6 sprinklers on 1¼-inch pipe, etc. The new or present pipe schedule is known as the 1-2-3 schedule, being 1 sprinkler on ¾-inch pipe, 2 sprinklers on 1-inch pipe, etc.

Loss Estimates.

These figures are necessarily very rough estimates. In the majority of fire reports there is an estimate of the amount of loss. In many reports the loss is noted as slight, moderate, heavy, etc. It is possible in some

cases to make a rough estimate of the amount of loss from the fire report where the actual amount is not given. By taking the average of loss for fires where loss is given, this estimate can be applied to the other fires in that division. A relatively few very large losses have an important bearing on the total loss in some divisions. In the following classifications, the division between small losses and large losses is not exact and ranges between $10,000 and $15,000.

Table 1.

Fires Extinguished or Held in Check.

Item		No. of Fires	Estimated Loss
1	25 to 50 sprinklers opened, small loss	462	$1,400,000
2	51 to 100 " " " "	153	780,000
3	101 to 150 " " " "	29	200,000
4	Over 150 " " " "	13	120,000
5	Class X—Large loss, over 24 sprinklers opened	12	300,000
6	Class Y—Large loss, over 24 sprinklers opened	79	2,200,000
7	Class Z—Large loss, over 24 sprinklers opened	66	2,500,000
8	Fires starting in unsprinklered sections—Large loss	8	350,000
9	Exposure fires—Large loss	15	850,000
10	Obsolete or generally defective equipments—Large loss	4	200,000
	Total for Items 1 to 10 inclusive, being fires Held in Check or Extinguished	841	$8,900,000

NOTE:—Items 5, 6 and 7 do not include fires classified in 8, 9 and 10. Items 1 to 4 inclusive are not classified as to occupancy.

Fires Classed as Unsatisfactory.

11	Valves closed, no water supply, system out of commission	204	$22,000,000
12	Fire started in unsprinklered portion of property	61	21,500,000
13	Exposure fires	11	2,500,000
14	Explosion wrecked sprinkler system	33	8,000,000
15	Failure of dry-pipe valve or dry system	11	1,500,000
16	Obsolete or generally defective system	26	2,800,000
17	Class X (exclusive of Items 11 to 16 inclusive)	2	200,000
18	Class Y (exclusive of Items 11 to 16 inclusive)	71	9,000,000
19	Class Z (exclusive of Items 11 to 16 inclusive)	67	9,000,000
	Total for Items 11 to 19 inclusive, being Unsatisfactory Fires	486	$76,500,000
	Total for all Items 1 to 19 inclusive	1,327	$85,400,000
	All other fires in this period (Deduct from 19,000 as an estimate)	17,673	17,600,000*
	Grand Total	19,000	$103,000,000

*NOTE:—This estimate is obtained by taking an average of about $1,000 a fire. One record of satisfactory control fires over a long period shows about $400 per fire. The loss in many cases is so small that "no claim" is made.

Table 2.
Losses by Classes of Occupancy.

	Class X (Mercantiles, etc. Warehouses of Ordinary Hazard)		Class Y (Manufacturing Properties of Ordinary Hazard)		Class Z (Extra Hazardous Properties)		Totals	
	No. Fires	Loss	No. Fires	Loss	No. Fires	Loss	No. Fires	Loss
Items 5, 6 and 7—Controlled, large loss	12	$300,000	79	$2,200,000	66	$2,500,000	157	$5,000,000
Item 8—Unsprinklered Sections	0		7	325,000	1	25,000	8	350,000
Item 9—Exposure	5	475,000	8	1,300,000	3	75,000	16	1,850,000
Item 10—Defective Systems	0		3	175,000	1	25,000	4	200,000
Item 11—Valves Closed, etc.	30	2,700,000	137	14,800,000	37	4,500,000	204	22,000,000
Item 12—Unsprinklered Sections	5	750,000	42	11,750,000	14	9,000,000	61	21,500,000
Item 13—Exposure	0		8	1,200,000	2	300,000	10	1,500,000
Item 14—Explosion	1	100,000	14	1,300,000	18	6,600,000	33	8,000,000
Item 15—Dry System	2	300,000	7	1,000,000	2	200,000	11	1,500,000
Item 16—Defective Systems	1	100,000	18	1,500,000	7	1,200,000	26	2,800,000
Items 17, 18 and 19—Unsatisfactory Control (Exclusive of Items 11 to 16)	2	200,000	71	9,000,000	67	9,000,000	140	18,200,000
Total	58	$4,925,000	394	$44,550,000.	218	$33,425,000.	670	$82,900,000

NOTE:—Items 1 to 4 inclusive have not been divided by occupancy classifications. Items 5 to 10 inclusive are Controlled Fires. Items 11 to 19 inclusive are Unsatisfactory Fires. Item numbers are explained in Table 1.

General Analysis.

While it is true that in many fires there are several factors which bring about unsatisfactory control, nevertheless in most cases the chief or controlling factor or factors are evident and the lack of control can be definitely assigned to such factors. The several items summarized in Table 2 may be analyzed as follows:

ITEM 5—CONTROLLED FIRES, CLASS X. There is one case of light water pressure (12 pounds) combined with serious obstructions from bins and stock; one case of old pipe sizes, under open joists, not staggered; and three cases where fire spread under open joists, standard spacing, with fire held in check. Slow dry system and obstructions were noted as contributing factors in two of these latter cases. The total loss under all of these light hazard (X Class) and satisfactory control fires was relatively unimportant.

ITEM 6—CONTROLLED FIRES, CLASS Y. There were two cases of light water pressure (15 and 7 pounds) and no other contributing cause noted. The hazard and conditions would easily account for the number of sprinklers that opened. There were nine fires with old pipe sizes (1-3-6) under open joist, not staggered, in some of which fires the spacing was undoubtedly an important factor. There were five cases with open joist, standard equipment. Defective sprinklers, quick flash fire, and some sheathing were contributing causes in three of these cases. There were two cases of slow action of dry system with contributing causes of low water pressure and quick spread.

There were a considerable number of fires where the chief or only reason for the number of heads that opened was the hazard and where sprinkler control is not criticized. These fires account for a large part of the loss in Item 6.

The losses in Items 5 and 6 figure about $250,000 a year and are relatively unimportant, being less than 10% of the reported controlled fires as a whole. Further refinement of protection would have little effect on these controlled fires. Fire spread under open joist construction in a few cases and fewer sprinklers would probably have opened with mill construction or smooth ceiling. Even these fires are of little importance as regards amount of loss. In no case was there any criticism of pipe sizes.

ITEM 17—UNSATISFACTORY FIRES, CLASS X. There are only two fires in this class, one a grocery warehouse and one a cheese warehouse. One was due to high ceilings (16 ft. to 36 ft.), piling of stock, and floor openings; the other to concealed spaces in walls.

ITEM 18—UNSATISFACTORY FIRES, CLASS Y. There were a large number of these fires, with total loss approximating $9,000,000. These may be analyzed as follows:

Obstruction to Distribution: There was one notable fire, where the obstruction to water reaching the fire was piles of burlap in bales. This might have been included in the Z occupancy. Three fires in paper mills where fire was under paper machine or engine. One carhouse fire, and one in a hull house of cotton seed oil mill. Conditions of construction and protection were generally satisfactory in most of these fires.

Light Water Supply: There was one fire where the pressure on the sprinklers operating was about 13 pounds. This was a weave mill with 1905 pipe sizes. There seems to have been no good reason for this severe loss.

Joist Construction, Old Standard: There were five fires in this class, two of them serious; again emphasizing that such systems with old pipe sizes, not staggered under open joists, cannot always be relied upon in manufacturing hazards.

There were fourteen fires with standard protection under open joists, several with unsatisfactory control and heavy loss. In most cases there were definite contributing factors, such as lack of water volume, obstruction from stock piles, etc. In several cases the fire spread in the ceiling, in some cases the construction was very light, pitch roof attics, high ceilings, slow dry system, etc. It seems clear that serious losses will sometimes occur under open joist ceilings, with generally good equipment, where conditions favor rapid spread of fire, with considerable combustible contents, such as found in a number of ordinary manufacturing properties, including paper mills, furniture factories, cigar box, hatters fur, porcelain works, blacking factory, linseed oil, veneer mills, leather works, etc. Nevertheless, the losses in this class are only about $100,000 a year, which is relatively unimportant when compared to many other items. Furthermore, where conditions are generally satisfactory, such as freedom from serious obstructions, floor openings protected, ample water pressure and volume, serious fires seldom occur under open joist construction with modern standard pipe sizes and spacing.

Piping or Sprinklers Clogged with Sediment: There were eight fires where piping or sprinklers were clogged or obstructed. While the loss over a period of years is not very large, it is possible that this feature may have been a factor in some other serious fires.

Hazard of Occupancy, Control Expected: This includes seven fires where quick spread was apparently the most important factor. In the

more serious fires under this classification, the following were contributing factors: light water pressure and oily conditions with 1-3-6 pipe sizes in a linseed oil mill; dryer and forced draft, high test heads, in a hat factory; 4 ft. bays, 1-2-4 pipe sizes in a rice mill (doubtful what happened in this case).

Miscellaneous: This includes several serious fires due to such factors as unreliable sprinklers, corrosion, slow dry system with draft conditions, and lighting. One very large loss was a fire starting in clothes locker, spreading to wooden walls, with slow dry system, oily floors, and open joist construction.

ITEMS 7 AND 19—CLASS Z (See Table 2). Item 14—Explosions—is also chiefly attributable to same occupancy Z. The total loss on these three items (including only Z of Item 14) approaches 2 million a year or nearly 20% of the whole.

An analysis of these fires seems to show that any weakness in construction, protection, water supplies, etc., may lead to serious loss. In such properties fire spreads very rapidly, a large number of sprinklers may open, overtaxing the sprinkler equipment and water supplies. Good construction and powerful water supplies are essential. Without these factors it is clear that fire will sometimes get beyond control.

The poor construction which often occurs in such classes as saw mills, grain elevators, chemical works, glass works, piers, etc., is an important factor in connection with serious fire losses in these properties.

Pipe Sizes.

This analysis includes fires with old as well as new pipe sizes. In a large number of cases the 1-3-6 schedule was used. No criticism of pipe sizes was noted even with the old schedule, although there were a few cases where the old pipe sizes may have been a contributing factor in manufacturing or extra hazardous properties. The fire record seems to show that under practically all conditions the old schedule (1-3-6) gives good protection if water supplies are satisfactory, and this is undoubtedly true except for severe hazards where a large number of sprinklers operate.

There were several fires where the control was not satisfactory due to the combination of open joist, 1-3-6 pipe sizes, and sprinklers not staggered. The spacing is probably far more important than the pipe sizes.

Where large numbers of sprinklers open, the problem is how to get enough water to feed so many sprinklers, and without enough water the pipe sizes are of no particular importance. On the assumption that less than ten gallons a minute is of questionable efficiency in most manufacturing properties, which would mean an average discharge of fifteen to

twenty gallons per minute for all sprinklers, it would often take more water than is available to feed fifty or more sprinklers.

Pipe sizes, spacing, and water supplies should vary according to the fire hazard, if the problem is simply one of obtaining adequate protection at a minimum cost. Based on the fire record it is at least open to argument whether the increase in cost of the present standard of pipe sizes over the old standard is warranted, as the old pipe schedule gives excellent results.

There does not seem to be anything in the fire record to show the need of pipe sizes as large as the present standard for such light hazards as mercantiles, hotels, institutions, etc. Sprinkler systems designed to feed 15 to 20 sprinklers would give satisfactory protection in many classes of property. The old pipe schedule has proven satisfactory for such hazards and in many such properties there is no need of risers or feed pipes over 2½ or 3 inch, depending on water pressures.

The present method of making pipe sizes large enough for the most severe hazard and then requiring the same large pipes in properties where the fire hazard is light, is illogical, and there should be varying standards of pipe sizes depending on the hazard and number of sprinklers likely to open in one fire. This would naturally lead to a piping standard for the light hazards (such as Class X), a standard for the ordinary manufacturing hazards (such as Class Y), and special treatment of pipe sizes, spacing, and water supplies for extra hazardous properties (such as Class Z).

At present there is only one standard for installing automatic sprinklers, and this standard is for all properties regardless of conditions. The owner of a property with relatively light fire hazard is compelled to pay considerably more than is necessary to obtain good sprinkler protection because he must install the same equipment as the owner of a property with severe hazard.

Spacing.

With the exception of open joist construction, the fire record does not seem to throw any light on the problems of spacing. Ceiling coverage is apparently of little importance except with joist construction. If the ceiling is fire resistive or slow burning, the fire cannot readily spread along or through ceiling and in most cases the sprinklers hold the fire in check sufficiently to permit easy extinguishment by such other means as may be available. It is probable that except under joist construction, the spacing could be extended somewhat, especially with light hazards, and still give complete and satisfactory control. The present approved types of sprinklers distribute water over a larger area than the area provided by present standard spacing.

It is admittedly a serious problem to prevent spread of fire along open joist ceilings. The floor area covered by each sprinkler under open joists is at present smaller than for most other types of construction and the fire record seems to emphasize burning through as well as spreading along joist ceilings. It is doubtful whether any reasonable change in spacing would show a marked improvement in fire control. Furthermore, the protection afforded by the present standard is highly efficient even under open joist ceiling.

It is doubtful whether any fire analysis would show any marked difference between various types of ceiling except with severe hazards. In all probability, if other factors were properly taken care of, the fire record for Classes X and Y would show satisfactory control with the present standard under joist ceilings. The fire record is remarkably good for joisted buildings, except where the hazard or other conditions are unusually severe, as in Class Z properties.

Here again, as for pipe sizes, it would seem to be wholly illogical to develop a standard for extra hazardous properties and then require such standard for all properties. The figures on fire losses show most remarkable results in the control of fire by automatic sprinklers and the conclusion may logically be reached that the present standard is too severe and more expensive than necessary for many classes of property, at the same time recognizing the fact that extra hazardous properties require special treatment.

Fire Loss.

This analysis covers fires in the United States and Canada over a period of nearly 11 years. Some large losses may not have been reported but probably most of these are reported. Many small losses are not reported. The total property loss is probably about twice the amount given below and can be roughly estimated at 20 million a year average over the period.

As a matter of interest, the insurable value of property in the United States, protected by automatic sprinklers, can be roughly estimated at 25 to 30 billion.

Assuming these figures are somewhere near correct, the remarkable results obtained through the use of automatic sprinklers are evident. Without automatic sprinklers the loss on these same properties would probably be 200 million a year or ten times as much as with sprinklers. Furthermore, this enormous saving in fire loss does not take into account the reduction in conflagration losses due to the large use of automatic sprinklers in business districts.

The losses included in this record may be roughly divided as given in the following table, figured on an annual basis.

Table 3. Losses in Sprinklered Fires.

A.	Controlled fires, small loss	$2,000,000
B.	Exposure Fires	400,000
C.	Closed Valves, etc.	2,200,000
D.	Unsprinklered portions	2,100,000
E.	Class X (Excluding A to D, inclusive)	100,000
F.	Class Y (Excluding A to D, inclusive)	1,500,000
G.	Class Z (Excluding A to D, inclusive)	1,900,000
		$10,200,000

From this it will be seen that the general question of changes in present standards is largely limited to F and G (Classes Y and Z).

Some of these fires were under sub-standard protection, such as lack of staggered spacing under open joists, weak water supplies, defective sprinklers, etc. Others under open joist with standard equipment, but with other factors which could have been eliminated. Clogged piping, serious obstructions, and dry systems were important factors.

The elimination of undesirable features in Class Y and the advisability of giving special consideration to protection, segregation, and control of hazards, in Class Z, seem to be the important features in these particular divisions of the fire loss. In extra hazardous risks the fire areas should be reduced to limit the number of sprinklers that may open, and water supplies must be provided to adequately supply all of these sprinklers.

Because of the inferior construction and large areas of some extra hazardous classes of property, large losses will sometimes occur almost regardless of sprinkler protection. On the other hand, even under such conditions, many or most fires are controlled, and the losses are only a small fraction of what they would be without sprinklers.

These figures show conclusively that the big problem is that of proper maintenance of the sprinkler system. If we refer to Table 2, the figures show that 45 million dollars loss in the uncontrolled fires is due to maintenance defects as against 26 million classified as due to hazards or explosion. Furthermore, a part of the latter 26 million is due in some degree to maintenance defects. It is, therefore, a fair statement that improvements in maintenance conditions are from two to three times as important as improvements in construction, protection, or hazard.

The fire record shows that the following should be kept in mind and practiced:

1. System should be complete.
2. It should be properly maintained, and valves kept open.
3. It should have at least one water supply of good pressure with volume adequate to the hazard.

4. Severe hazards which may open a considerable number of sprinklers should be segregated and restricted, with such special protection as may be needed; the sprinkler system to be designed to properly feed the number of sprinklers that may open.

N.F.P.A. Classification.

The number of fires classified as "Failures" or "Unsatisfactory" in the Sprinkler Tables published in the April issue of the QUARTERLY each year includes many fires which are of no importance, where the loss is small, where only one or two heads are affected, etc. It also includes a number of fires where the sprinklers were of much assistance in controlling the fire and which could be classified as helping to "hold in check," even though the result was not wholly satisfactory.

The following analysis divides the fires into two main classes, controlled and uncontrolled, the latter being largely fires where the loss was considerable. It excludes fires where the equipment was intentionally out of service or abandoned. This presents the relation between satisfactory and unsatisfactory fires somewhat differently from the N.F.P.A. Tables. Even these figures, however, present far from a correct picture of the efficiency of automatic sprinkler protection, for two reasons:

1. The large losses are generally reported while probably only half or even less of the small losses are reported.

2. The analysis includes unsatisfactory fires where the equipment was generally defective, or obsolete, and the percentage of controlled fires would be greater if these were excluded.

This analysis shows:

	No.	Per Cent	Loss	Per Cent.
Fires Extinguished or Held in Check	18,514	97½	$26,500,000	25
Unsatisfactory Control of Fire	486	2½	76,500,000	75
Total	19,000		$103,000,000	

If it were possible to classify all fires, and eliminate old and defective equipments, the unsatisfactory fires would probably not exceed one per cent of the whole. Proper maintenance and complete systems might bring about a reduction of one-third of this entire loss.

The N.F.P.A. Fire Record includes a classification of Unsatisfactory Fires according to causes or conditions which were responsible for the unsatisfactory results. This classification is by number of fires. The following classification is by amount of loss, which gives a better idea of the importance of each of these conditions and shows the approximate relative effect of each on the amount of loss (unsatisfactory control) during the period 1916-1926, which latter is about 75 million.

Table 4.

Unsatisfactory Sprinkler Fires Classified by Amount of Loss.

1.	Closed Valves, etc.	30%
2.	Unsprinklered sections	28%
3.	Severe hazard and explosion	19%
4.	Obsolete or generally defective systems	7%
5.	Exposure	3%
6.	Weak water supply	2%
7.	Dry-pipe systems	2%
8.	Defective sprinklers	1½%
9.	Unsprinklered enclosures	1%
10.	Clogged piping	1%
11.	Obstructions to distribution	1%
12.	Floor openings	1%
13.	Miscellaneous; clogged pipes, corroded sprinklers, etc.	3½%
		100%

Nos. 3, 4, and 5 have no definite relation to maintenance of the average system. Therefore, about 70% of this loss is due to lack of proper maintenance or incomplete equipment. If the losses from unsprinklered sections are also deducted there remains about 40% of the loss due to purely maintenance features of a complete system. This would seem to teach a lesson which is not always appreciated, namely: improvement in maintenance conditions of automatic sprinkler systems is far more important than the details or refinements of the Sprinkler Rules.

Also the following is worthy of very careful consideration. The old standard or inferior system, as measured by present standards, is highly efficient except with severe hazards of occupancy. The cost of sprinkler protection under present standards seriously retards the extension of such protection in many properties, particularly those where the property value is relatively small compared to floor area, and the fire hazard comparable to or less than mercantile properties. A sprinkler system can be designed for such properties which is much less expensive than the present standard and which will give adequate and satisfactory protection.

Sherry-Netherlands Hotel Fire.

By Wm. B. White (Member N.F.P.A.).

Superintendent, Bureau of Surveys, New York Board of Fire Underwriters.

The spectacular nature of this fire in the Sherry-Netherlands Hotel, New York, and the practical helplessness of the fire department in combating it, has emphasized several important fire protection measures which are absolutely necessary in buildings of the "skyscraper" type. The fire occurred at 7:45 in the evening of April 13, 1927, and raged for nine hours until it had burned itself out.

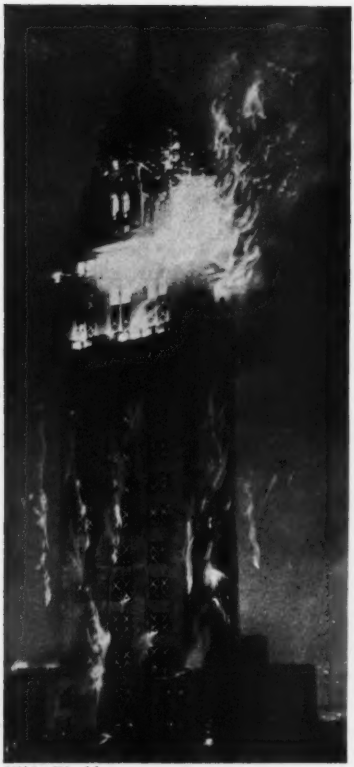
The building was under construction and its exterior was practically finished except for the top portion of the tower, where there was considerable frame scaffolding. Two frame hoists also extended from the first floor on the outside of the building to the cupola. The structure is of the modern fire-resistive type, some 12,000 sq. ft. in area up to the 17th floor. From the 17th to the 23rd floor set backs reduce the area to 3,000 sq. ft. and a tower of this area extends to a point 38 stories above the street with the cupola extending approximately three stories higher.

There are two enclosed stairways extending from the sub-basement to the tower, one of these extending to the 38th floor. Four elevators extend to this 38th floor. There are no smokeproof fire towers in the building.

The only fire protection was an uncompleted standpipe installation. At the time of the fire tanks had been installed in the tower and on the 23d and 12th floors and two 8 in. standpipes were in position, one of them extending to the tower. This standpipe to the tower had not been connected to the tank and was uncapped. Also a cross connection between the two standpipes on the 22nd floor was uncompleted, and only one of the four siamese connections at the street was finished, although all check valves were in.

No definite cause can be assigned to the fire, although it may have started from the charcoal furnace of a tinsmith, which had been in use in the vicinity of the fire. At just about dark, it was noted from the street that the scaffolding was ablaze at about the 38th floor and a patrolman turned in an alarm to the fire department. In all five alarms were sounded.

Fire department attempts to send water to the location of the fire were fruitless. Connections were first made to standpipe outlets on the lower floors, but the uncompleted cross connection on the 22nd floor prevented water from going higher. The fire department reports that its men finally inserted a piece of pipe at that point and closed up the cross connection, but not very satisfactorily, for they were unable to obtain or



Wide World.

Underwood and Underwood.

The left-hand picture shows the burning scaffolding of the Sherry-Netherlands Hotel with the blaze at its height. Burning beams and embers showered the surrounding property during the fire doing considerable incidental damage. At the right is a view taken the morning after.

maintain the pressure required. It also appears likely that water escaped from the system through faulty seating of a check valve in one of the siamese connections.

There is some doubt whether the fire department could have delivered water at the top of the building, 500 ft. high. To do this an estimated pressure of 300 lbs. per sq. in. would be required, and as it was, the fire department burst many lengths of the hose connecting their pumpers with the standpipes. Some of these breaks were due to burns on the hose from falling timbers.

Unimpeded, the fire spread rapidly throughout all the scaffolding on the tower and soon involved the two frame hoists on the north side of the

tower. The damage was chiefly to the exterior of the building and to the elevator machinery at the top of the tower. Steel H-columns at the top of the tower which had not been protected with "fireproofing" material buckled while the protected ones were not damaged. This emphasizes the need of fireproofing all supporting steel members as promptly as possible. The practice of delaying the fireproofing of columns on the first floor of buildings because ornamental or special coverings are to be provided, may allow a fire to wreck the building and is a menace to individual and public safety. Falling and burning timbers showered the surrounding buildings during the fire doing considerable incidental damage. The loss amounts to over $500,000.

The lessons of this fire are as follows:

1. The hazard of combustible scaffolding is illustrated. At least the supporting members and the enclosure of such structures should be of incombustible materials.

2. The amount of combustible and flammable material piled on the various floors of high buildings under construction, the use of salamanders and other portable heaters, combustible scaffolding, and temporary construction and general smoking by workmen are all reasons for providing first aid fire appliances. Hand extinguishers are effective, and a forty-gallon chemical can take care of a fairly good sized incipient fire.

3. The presence of the above hazards emphasizes the need for maintaining during construction as well as thereafter a fully enclosed hoist or elevator to get firemen and hose to a fire quickly. The fire department was in this fire greatly hampered by the lack of such a device, men being obliged to toil up stairs with heavy hose.

4. Because the building was a hotel and not an office building the New York Building Code does not require an enclosed fire-resistive smoke-proof tower. The code is inconsistent in requiring such a tower for office buildings over 85 ft. high and omitting any such requirement for hotels and apartments where the life hazard is much more severe. Another reason why they should be required in all such buildings is because of their value to firemen in fighting a fire.

5. The importance of installing standpipes in buildings in the course of construction and maintaining such systems in proper condition for use by the fire department at any time as required by law was here disregarded. Evidently stringent measures such as a "Stop Order" or the revocation of licenses are necessary to enforce this requirement as it is entirely impractical for an inspector from any department to actually police the building.

This fire also raises the question of the adequacy of the water distribution system in this part of the city, the advisability of extending the high pressure system to this section, and especially demonstrates that in high buildings the responsibility for protecting them should lie with the owners, who should be required to install and maintain fire pumps, standpipes and an enclosed elevator hoist accessible to the fire department at all times, including the period during which the building is being erected.

An Underground Gasoline Tank Explosion.

An explosion in underground storage of gasoline at Lakewood, Ohio, last winter, under conditions which would have seemed to make such an occurrence impossible, is reported by Mr. C. S. Magruder of the Ohio State Department of Fire Prevention, Secretary of the N.F.P.A. Fire Marshals Section. Reports from Chief J. H. Speddy of Lakewood, and from the Ohio Inspection Bureau (Member N.F.P.A.) confirm the details.

On January 17 an explosion occurred in a small dry cleaning establishment in Lakewood; there was no one in the plant at the time. The original cause was not definitely determined but was thought to be a static spark in a washing machine. The ensuing fire was promptly extinguished with chemical extinguishers and wet rags. The loss in the plant was slight, the garments in process of cleaning being undamaged.

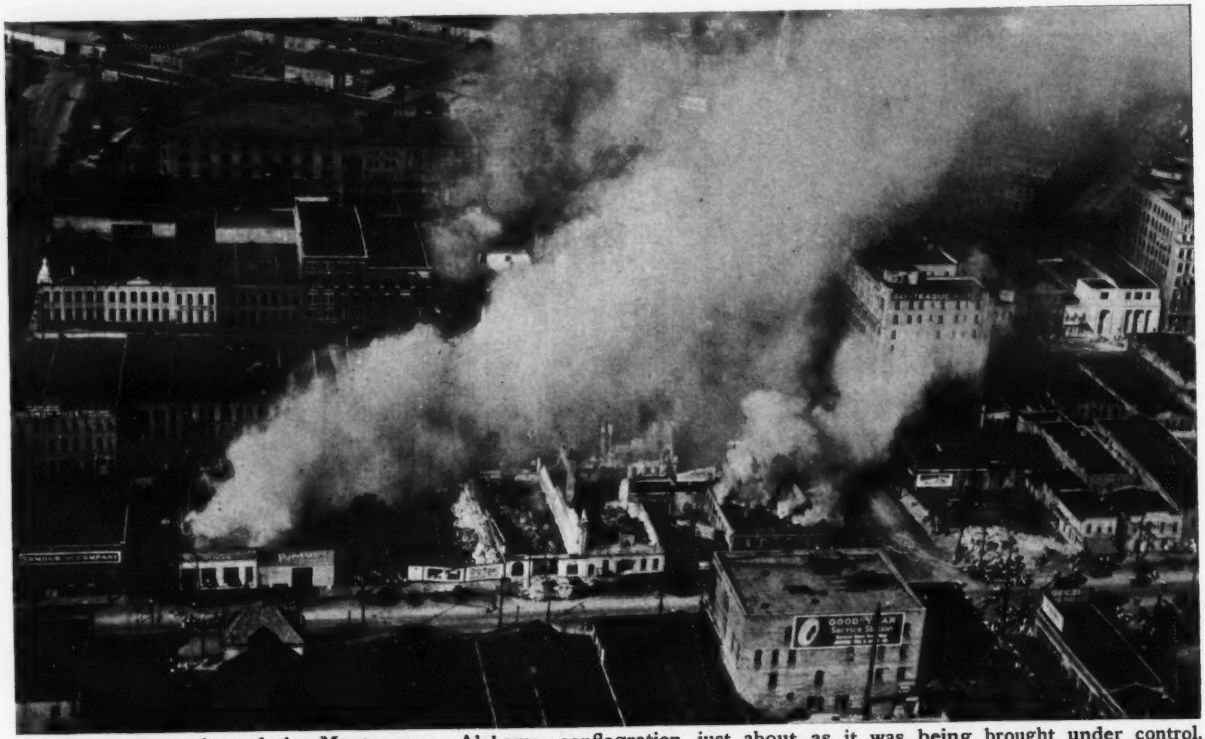
The equipment in this plant was that usual to the dry cleaning occupancy, washing machines, extractor, tumbler, gasoline purifier, gasoline pump, etc. The fire was practically confined to one of the washing machines, and there is no evidence that there was any fire or explosion in connection with the gasoline pump or purifier. How the explosion propagated to the underground tank is a mystery. The gasoline was fed to the machines by gravity from the filter, and the machines were provided with drains to the underground tanks. At the time of the explosion the only open connection between the underground storage and the washing machine where the explosion apparently originated was a vent hole three-eighths of an inch in diameter in a pipe connecting with the drain. The evidence indicates that explosion or fire could not have traveled from the building to the underground tank by any other path. But this drain pipe entered the underground tank near the bottom, below the liquid level. When the tanks were excavated two days after the fire they were half full of gasoline, and it appears very unlikely that gasoline ran into the tank between the time of the explosion and the day when the tanks were dug up. Even if the liquid level had been below the pipe at the time, theoretical considerations would indicate that the gasoline vapor and air mixture would be too "rich" to explode, as long as there was liquid gasoline in the tank. One theory is that owing to the cold the gasoline evaporated slowly and thus formed a mixture with air in proportions favorable for an explosion, but this theory must be discarded in view of the fact that the

These gasoline tanks were buried between four and five feet underground, the installation apparently in accordance with the best practice, but an explosion propagated to them, blowing the end off the 550 gallon tank and denting the 250 gallon tank. This photograph was taken just after the tanks had been dug up and before any repairs had been made.

tank was buried with its top more than four feet below the surface of the ground and was thus insulated against the cold. This depth below the surface of the ground would also preclude the possibility of ignition by heat from the fire; it also should be noted that the tanks were buried outside of the building and that there was no fire directly above them.

The underground explosion must have been rather forceful, as despite the fact that the surface of the ground was frozen, and was covered with about a foot of snow at the time, it looked like plowed ground after the explosion. This observation is substantiated by the appearance of the tank in the illustration, which indicates an internal explosion of no little force.

Though no plausible theory has yet been presented, there must be some scientific explanation of this explosion. But until some explanation can be found this case will stand as an example of the frequently cited vagaries of gasoline, about which there seems to be still much to be learned.



An airplane view of the Montgomery, Alabama, conflagration just about as it was being brought under control. Starting in a junk yard on Lee Street (left foreground), the fire was quickly out of control of the fire department and destroyed twenty-two buildings in the mercantile district of the city, doing a damage of about $1,500,000. *P. & A.*

Montgomery Conflagration.

Report by South-Eastern Underwriters' Association.

(Member N.F.P.A.)

Montgomery, Alabama, was visited by a conflagration on June 4, 1927, which, starting in a junk pile in a closely built section of the city, spread readily through unprotected openings to buildings of inferior construction and destroyed a large portion of two city blocks before it burned itself out. The loss is estimated at $1,500,000.

The accompanying map shows the extent of the fire. The twenty-two buildings destroyed were principally of brick joisted construction, varying from one to four stories. One of these was equipped with automatic sprinklers. The other occupancies were wholesale and retail mercantiles with three hotels and two junk yards included. Slight damage was done to some eleven other buildings, six of which are protected with automatic sprinklers and one of which is fire-resistive.

The junk yard in which the fire started was located as shown and was piled about six feet high with waste paper, oil soaked rags, crates, burlap, and other flammable materials. As nearly as can be ascertained, the fire was started by a driver of a one-horse wagon load of waste paper which was being unloaded in the junk yard, the man having dropped a lighted match beneath the wagon. The fire spread rapidly and destroyed the wagon and burned the horse to death.

On account of frequent fires there to burn off insulation from fires and to destroy other waste materials, the fire in the junk yard was not noticed by employees or others in the vicinity until it was observed by employees on the fourth floor of a building located about one block north who notified the fire department by telephone at 1:02 P. M. It is believed, therefore, from the progress the fire had made before the fire department arrived that at least five minutes had elapsed between the time the fire started and the time the fire department was called.

From beneath the wagon the fire spread rapidly to the frame junk shed and the frame metal clad storage shed of the Cudahy Packing Company. From the frame sheds the fire was communicated to two furniture trucks in the alley and to the rear of five three-story brick, ordinary joisted mercantiles through unprotected openings. This involved a heavily stocked retail furniture store and warehouse from which the fire spread rapidly to the other buildings in the block.

At about this time the fire department arrived at the junk yard and laid hose lines from pumpers and hydrants. Five sections of hose burst as

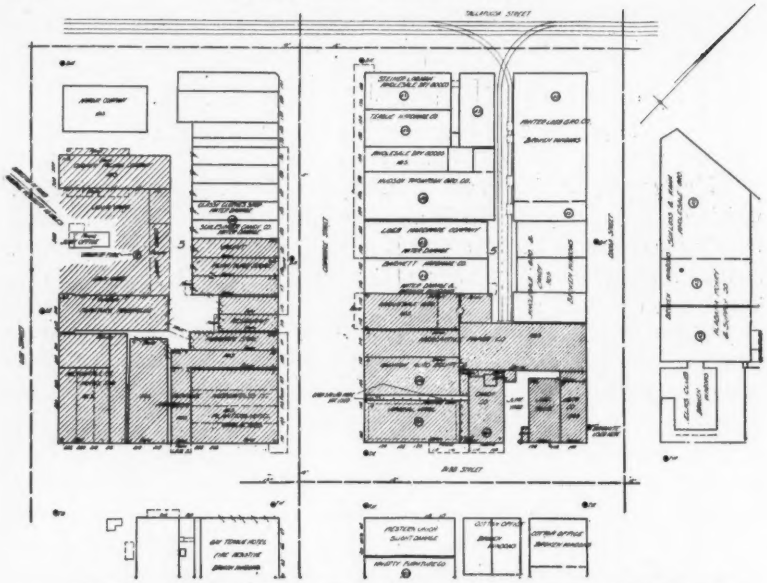


Diagram of the buildings involved in the Montgomery, Alabama, conflagration of June 4, 1927. Shaded area indicates buildings totally destroyed. The fire started in the junk yard at the upper left and spread with the wind through the better part of two city blocks, crossing Commerce Street, which is 120 ft. wide. Two sprinklered buildings served as important fire stops. The airplane picture on page 98 was taken looking from the left of this plan.

soon as put in service and this caused considerable delay. The assistant chief of the fire department who was in charge, then realizing his inability to cope with the fire, turned in a general alarm.

The additional apparatus was stationed at the corner of Commerce and Bibb Streets and put two streams into play on the buildings then burning near the corner. The fire was of such intensity, however, that the firemen were forced to abandon these streams and to move their apparatus, thus causing a delay of about 15 minutes. During this time the fire jumped the 120 feet across Commerce Street to a paper warehouse, a wholesale grocery store, and an auto accessory shop. The latter was protected by an automatic chemical extinguisher system which operated but was quickly exhausted.

The fire spread northwest along Commerce Street but was stopped by a sprinklered hardware store. A four-story brick joisted sprinklered hotel building at the corner of Commerce and Bibb Streets stopped the spread of fire to the south, but this building is practically a total loss because fire communicated to its frame mansard roof. There were manually operated

Where the fire was stopped at the corner of Bibb and Coosa Streets. After the fire was under control some unauthorized persons exploded a charge of dynamite in the corner building, making a hole at the bottom of the wall at the right of the corner.

open sprinklers to protect exposed windows on the north and east sides of this building, but these were not used.

The operation of the sprinklers in the hotel building on the south and the hardware store on the north narrowed the course of fire, however, to a point terminating at the east corner of Coosa and Bibb Streets and here the concentrated efforts of the fire department finally stopped the fire.

After the fire was under control some unknown person, without permission of the civil authorities, placed and exploded a heavy charge of dynamite on the sidewalk against the east wall of a garage. The explosion did not demolish the building, but resulted in seroius damage to glass and other property in the vicinity.

The fire obtained such a start before the alarm was turned in that the fire department was at a disadvantage to begin with and with the bursting of hose and other delays, the fire department apparently became demoralized and lost control of the fire. It was aided by apparatus and men from the Maxwell Aviation Field, Selma and Wetumpka, and apparatus was sent from both Troy and Birmingham, but in these cases arrived too late to be of assistance. Apparently the water supply throughout the fire was adequate.

This fire serves to emphasize the hazard of permitting junk shops and junk yards in mercantile districts or within the fire limits. It also emphasizes the seriousness of a delayed alarm and the importance of testing and discarding faulty hose.

Fires in Which There Was Loss of Life.

These notes are intended to point out typical conditions under which loss of life has occurred that they may be known and guarded against.

Flash Fire in Flammable Solvents.

S-44943. CLEVELAND, OHIO, APRIL 13, 1927. PYROXYLIN LACQUER FACTORY. This fire caused the death of three men and seriously burned another, and did considerable property damage. It started in the room where the lacquer is "cut" or thinned by the addition of solvents, probably from a static spark from a slipping belt driving the churns. A mechanic was in the room with the churn operator when a flash occurred. It knocked the operator down and blew the mechanic out of the churn room into a main work-room, and also knocked down two men in the main room. The fire spread so quickly that a man attempting to put out the fire with a 2½ gallon foam extinguisher in order to rescue his fellow workman in the churn room was badly burned and later died.

Air Compressor Explosion.

S-44963. BUFFALO, N. Y., MARCH 16, 1927. ELECTRIC TRUCK FACTORY. Six men were riveting metal frames using an electric rivet heater and compressed air to drive the rivet machines. Suddenly the compressor exploded, showering the men with blazing carbon dust, and igniting everything combustible in the room. The six men were so badly burned that four of them died within a few hours and another died later. The excessive use of lubricating oil in the air cylinders of the compressor caused the explosion. The high temperature from compression ignited the volatile constituents of the oil and the explosion scattered accumulated carbon from the machine.

Gasoline.

H-24322. OAKLAND, CALIF., FEBRUARY, 1927. GARAGE. An underground tank in the garage suddenly overflowed while being filled with gasoline from a tank truck. Before the stream could be shut off, two rivulets of gasoline poured along the concrete floor of the garage. One stream ran into the ashpit beneath the furnace and caught fire. There was a roaring burst of fire as a two-inch geyser of blazing gasoline from the underground tank shot up to the ceiling, and then scattered in all directions. A moment later the tank blew up, covering the unfortunate driver of the tank truck with the burning liquid, and blowing out every window in the building. One man turned a hose on him, knocking him down and adding to the seriousness of his injuries. He died from his burns.

H-24346. LYNN, MASS., MARCH 25, 1927. JUNK YARD. An employee was at work burning paint off the bodies of wrecked automobiles with a gasoline torch. While cars are supposed to have all gasoline and oil removed before the gasoline torch is applied, in this instance a full gasoline tank was overlooked and exploded when the heat of the torch was applied. Both the employee's arms and legs were broken from the shock, and his gasoline soaked clothing ignited. He crept to a faucet and attempted to turn on the water, but his strength was not equal to the task and he collapsed. Regaining consciousness he crawled to the street and attracted the attention of a motorist, who took him to the hospital where he died.

H-24382. PARCO, WYO., APRIL 6, 1927. OIL REFINERY. Sixteen men were killed and six injured by an explosion. The disaster was caused by the explosion of a chamber in a high pressure still which set fire to nine other stills, and two storage tanks.

Cleaning with Gasoline.

L-116. DECATUR, ILL., APRIL 24, 1927. One woman was fatally burned and another woman and a two-year-old child badly burned by an explosion of cleaning fluid. Naphtha, which was being used to clean a dress, was brought too near a lighted gas-plate and caught fire. The flash ignited the clothing of the three occupants of the room, with the above results.

L-125. NEW YORK, N. Y., JUNE 19, 1927. Two children, four and two and a half years old respectively, were burned to death in the kitchen of their apartment when a gasoline saturated rag with which their mother had been cleaning clothes became ignited. The bodies of the two children were found clasped in each other's arms under a wash tub. The mother was able to rescue three other children before the flames filled the entire room. She was slightly burned in doing so.

Fighting Incipient Fire.

H-24499. WASHINGTON, D. C., APRIL 23, 1927. SORTING AND STORAGE OF WASTE PAPER. Fire started in a bin on the second floor into which paper was dumped through chutes from the third floor. The exact cause is not known, but may have been due to spontaneous ignition. All the employees with the exception of the manager left the building at once. He remained to fight the fire and after the fire was extinguished his body was found at the elevator on the third floor. He had evidently attempted to leave by way of the elevator, which apparently jammed, and he was overcome before he could get to the stairway.

Salvage.

L-112. 6 MILE ROAD, CUMBERLAND COUNTY, N. S., MAY 11, 1927. An aged couple were burned to death while attempting to save the furniture from their dwelling. Their deaths occurred about a half hour after the fire started, which was probably caused by a defective flue.

Smoking in Bed.

L-118. TROY, N. Y., MAY 2, 1927. A woman was smoking a cigarette in bed and fell asleep with the cigarette in her hand. The cigarette ignited the bed clothing and she was fatally burned.

Children Playing with Matches.

L-114. BROCKTON, MASS., APRIL 19, 1927. A four year old girl was playing in the yard of her home when one of her playmates tossed a lighted match on to her flimsy clothing. She was so badly burned that she died later in the hospital.

L-124. MEDFORD, MASS., JUNE 17, 1927. A group of children were setting off fireworks and one little girl had a handful of matches. While running with them she fell and the matches ignited and set fire to her clothing. Her entire body was burned and she died in the hospital the same day.

L-126. QUINCY, MASS., JUNE 18, 1927. A three-year-old child died in the hospital from burns she received while playing with matches.

Fire Fighting.

H-24548. LAKE OWASSO, MINN., APRIL 10, 1927. CHILDREN'S PREVENTORIUM. The building, a large frame structure, was used as a dormitory and had a dining hall attached. Fire which started from an unknown cause was first seen coming through the roof. Firemen entered the building and were trying to save some of the contents. While thus engaged one of their number was trapped in a room by the falling of part of the floor and ceiling of the attic. This blocked the door and knocked him down, igniting his clothing. Although stunned, he jumped to the ground where the fire in his clothing was extinguished, but he died from his burns a few hours later.

H-24591. HARRISBURG, PA., MAY 8, 1927. PRINTING PLANT. Two firemen lost their lives and seven others were injured in a fire which destroyed the state printing plant. It was not until hours after the fire that the body of one of the men was found on a portion of the third floor of the building which had not collapsed. The body of the other fireman was not located until long after the fire was extinguished.